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PROGRESS REPORT  
of the  
AGRICULTURAL ENGINEERING RESEARCH DIVISION  
AGRICULTURAL RESEARCH SERVICE

This progress report includes a summary of the current research of the Division and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between April 1, 1967, and / March 31, 1968. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C.

UNITED STATES DEPARTMENT OF AGRICULTURE

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## INTRODUCTION

Agricultural Engineering Research as used in this report is concerned with the applications of engineering principles to agricultural production and rural living. More specifically, it deals with the power, machines and structures required, and includes (a) development of new and improved equipment for the more effective mechanization of seedbed preparation, fertilization, planting, cultivation, pesticide application, harvesting and farm handling of crops, and studies of the more efficient use of such equipment; (b) development of more effective and lower cost buildings and equipment for the handling and sheltering of livestock, including research in functional requirements, for the handling and storing of farm commodities on the farm, and for farm living; (c) development of more effective methods and equipment for the mechanical preparation and conditioning of farm products for farm use or sale, including such testing and quality determination as needed to adequately evaluate research results, and (d) adaptation and development of methods and equipment for effective and economical farm and rural applications of electric energy, used as power, heat, light, and other electromagnetic radiations for plant and animal production, farm processing, and rural living.

The importance of Agricultural Engineering research to the nation's agriculture is shown by the fact that power, machines, and structures with which it is concerned are essential facilities for every farm. Also, the solutions of most plant and animal production problems are in part determined by the machines and structures available and likewise almost every new finding in soil, plant, or animal science research requires additional engineering research for its most effective implementation. As the relative cost of labor increases and the mechanization of agricultural operations progresses, engineering research becomes increasingly important. Since the close of World War II the annual man-hours of farm labor have been reduced by 55 percent, from 18.8 billion to 7.5 billion, the number of tractors has doubled, from about 2.4 million to 4.8 million, and the percent of farms served by electric power lines has also doubled from about 48 to over 98. Each farm worker has available between 35 and 40 mechanical and electric horsepower. The investment per worker for land and other facilities, which is higher than for all manufacturing, averages over \$65,000. For many farms it is more than \$100,000.

However, in spite of the rapid and unprecedented progress in farm mechanization during recent years, many important field and farmstead operations are still not mechanized or are only inadequately mechanized. There are also many unsolved problems in the mechanical preparation and conditioning of farm products for farm storage and use, and for sale. There are many undeveloped opportunities for the more effective and extensive application of the different forms of electromagnetic energy and there is urgent need for the development of more effective and economic farm buildings for storing products, sheltering livestock, and farm family living.

Agricultural Engineering research is carried out by the Agricultural Engineering Research Division of the Agricultural Research Service of the U. S. Department of Agriculture, by nearly all of the State Experiment Stations, and by farm equipment manufacturers, manufacturers of building materials and prefabricated buildings, and to a limited extent by trade associations.

A characteristic of current Agricultural Engineering research is the relatively small program of the USDA and also of the State Experiment Stations in this field compared to that of public research in other fields of agriculture. This imbalance is serious because 80 percent or more of all agricultural research involves engineering, either during its conduct or during the application of its positive findings. Also as agriculture becomes more complex the need for expanded public agency research in agricultural engineering to determine for industry the fundamental principles and the basic requirements of the power, machinery, and structures needed for an efficient agriculture become increasingly urgent.

In commenting on Balance among Phases of the U.S.D.A. Research Program in its report of April, 1965, the National Agricultural Research Advisory Committee stated, "Problems in agricultural research are constantly changing in relative importance necessitating a periodic review to maintain a proper balance. -----

It believes the current level of engineering research both on the part of the USDA and the State Experiment Stations is too low."

The 1966 report of the National Agricultural Research Advisory Committee in commenting on Protection of Man, Plants and Animals, recommends intensifying all phases of research in waste disposal including the utilization of waste from farms. -----

In commenting on Efficient Production and Quality Improvement, the committee reaffirms its previous recommendation-----and that increased emphasis be placed on agricultural engineering studies with the objective of achieving an agricultural industry that is more productive, efficient, and profitable.---

The Committee recommends that a completely new look be taken at forage harvesting, transportation, storage, and feeding to achieve significantly improved efficiencies in handling and digestibility. It also recommends enlarging the research effort on controlled environmental studies of livestock and poultry. It also points out the serious lag in mechanization of milking compared to other areas.

Thus, although there is need for the expansion of independent basic research in agricultural engineering, there is also need for a considerable expansion of agricultural engineering research cooperative and concurrent with other related agricultural research programs and also cooperative with industry whenever circumstances indicate the desirability of such cooperation. It should be noted that public agency research in agricultural engineering is complementary to and often cooperative with private research and not a competitive duplication of research by industry.

The Agricultural Engineering Research Division has 28 of its 173 professional workers located at the Beltsville Agricultural Research Center; 45 at 16 federal field stations, and 100 at 38 State Experiment Stations.

Most engineers are working cooperatively with State-employed workers on mutually agreed problems that have both State and National significance. Much of the research is carried on by teams including both engineers and scientists trained in other disciplines.

The program at Beltsville includes leadership for work done in the field and research on problems of National interest. Basic research in the Division deals with soil and equipment relationships, pesticide application, crop conditioning, cotton ginning, environmental requirements (including light) for livestock, electromagnetic radiation for seed and plant product treatment, and insect attraction and destruction. Most of the work at other locations is directed toward solution of specific problems.

As a step toward implementation of the recommendations for a National Program of Research for Agriculture made jointly by the Association of State Universities and Land Grant Colleges and the USDA, examples of achievements resulting from State and State-USDA cooperative research are shown.

The program of the Agricultural Engineering Research Division is reported under Research Problem Areas shown in the Table of Contents.

The following examples are illustrative of research accomplishments for which the Agricultural Engineering Research Division (AERD) has had a major responsibility:

(1) New Standards for Migratory Agricultural Worker Housing. New standards have been developed for housing of migratory agricultural workers. ARS and PHS researchers created new designs and built prototypes which will provide the migrant and his family a more healthful and livable housing. The housing is also more economical for growers to build, alone or collectively.

(2) Cotton Unloading System. ARS engineers at the U.S. Cotton Ginning Research Laboratory at Stoneville have developed an unloading system for gins whereby a trailer can dump its entire load into a receiving bin in one sweeping movement. Gins currently use a sucker pipe system and, for a 20 bale-per-hour gin, three or four men and 120 horsepower are required. The new unloading system reduces labor requirements 50 percent, cuts horsepower up to 95 percent, and assures an adequate supply of raw cotton to the gin. The receiving bin can be designed to hold any desired quantity of raw cotton at one time. It is equipped with a conveyor belt and feed rollers that convey the cotton from the gin to hot-air pipes that carry it to drying and cleaning machinery. Commercial adoption is underway.

(3) New Home Heating System Developed. A new low-cost and highly effective peripheral heating system for homes has been developed by Agricultural Engineers. The system has been installed and tested in two

one-story houses where the temperature difference from floor to ceiling ranged only from 2° to 5° F. In a conventionally heated home these differences are frequently 15° to 20° F.

Tests show that under normal living conditions, a peripheral circulation system can be incorporated in a one-story house during construction for from \$100 to \$200. It may also be incorporated as a part of an existing central-heating system to improve circulation. The peripheral circulation system is especially suited for one-story houses with a crawl space or those built on slabs with wood floors laid on sleepers.

(4) Peanut Harvesting. Cooperative studies by ARS engineers have shown that peanuts dry faster and more uniformly when turned upside down in windrows than if dug and windrowed in random fashion. The inverted windrows offer the advantages of better exposure for drying, less chance of molding, and reduced harvesting losses. ARS engineers are developing equipment that will dig peanuts and place them upside down in windrows in the same operation. Most present diggers place peanuts only in random rows. If high moisture peanuts are placed underneath the windrow and in contact with the ground, which happens frequently in random windrowing, they may mold during damp or rainy weather. Moreover, losses may increase during combining due to the weakening of stems which connect pods to the plants. Several manufacturers have recently undertaken development of similar equipment.

(5) Automatic Equipment for Dairy Feeding. An integrated feeding system has been developed using automatic equipment to remove silage from an upright silo, properly proportion and mix concentrates with it, and deliver the feed by conveyor to dairy cows. Among "key" components of the system are solid-state speed-regulation controls. These operate d.c. motors which drive the winch for the cable supporting the silo unloader and drive the auger-type feed meters dispensing concentrates, thus providing measured flow of each ration ingredient. Although the system can be automatically operated by a timeclock, it is deemed best to require the herdsman to start its operation to permit observation of its performance. However, reliability has been demonstrated by nearly a year of trouble-free operation. Such equipment will contribute significantly in reducing labor requirements and eliminating drudgery in dairy "chores."

(6) Corn Sheller. A new corn shelling unit that prevents kernel damage during harvesting is being field tested by ARS engineers in cooperation with Iowa State University. The new unit has thick rubber belts that hug the ears and squeeze off the kernels. Gentle squeezing, the engineers hope, will eliminate damage to the kernels. Almost half the commercial corn crop is shelled in the field by mechanical shellers that remove kernels by force of impact. Engineers estimate that such machines damage 30 percent or more of the kernels. When kernels are damaged, the rate of biological activity increases. Cracks in the skin of the kernels provide open doors for organisms to enter the seed, lowering the quality of the stored corn and speeding spoilage and deterioration. The experimental corn-shelling unit is expected to reduce damage by 90 percent.

SOIL STRUCTURE  
AND SOIL, PLANT, WATER, NUTRIENT RELATIONSHIPS  
RPA 102

USDA and Cooperative Programs

Location of Intramural Work	Subject	Scientist Man-years FY 1968
Alabama (Auburn)	Soil-working Tools	6.5
	Tillage Systems	1.5
	Traction and Transport	1.0
	Tillage Systems	2.0
Iowa (Ames)	Total	11.0
India (Kharagpur)	Traction and Transport	PL-480
Israel (Rehovot)	Tillage Systems	PL-480
Italy (Bologna)	Soil-working Tools	PL-480
Poland (Warsaw)	Soil-working Tools	PL-480

Intramural program is supplemented by extramural support representing (a) 0.0 SMY's at State Agricultural Experiment Stations, (b) 0.0 SMY's at other U.S. institutions and (c) PL 480 funds in four countries representing \$53,149 U.S. dollars equivalent.

### Problems and Objectives

Tillage of the soil is the greatest consumer of energy in the production of crops in the United States today. Some type of tillage is considered necessary to prepare the soil for the growing of most crops, yet there is considerable evidence that present practices often do not provide the optimum physical conditions for plant emergence and growth. The soil is a very complex physical system containing organic and inorganic solids, liquids and gases. Its response to forces, manipulation, temperature, moisture and other factors is unlike any other simple material.

There are also indications that compaction of tilled soil is becoming more common. This is considered to be caused in part by increasing weight and frequency of wheel traffic. Both tractors and machines are increasing in size, and more complete mechanization of field operations tends to increase the number of wheel passes over a field. Soil compaction in the root zone of growing plants reduces yields through decreased water infiltration, decreased soil aeration and increased root impedance.

Major objectives of research are:

1. To determine the inter-relationship of tillage, soil physical conditions, and plant growth.
2. To determine the effect of soil mechanics and equipment mechanics on the tillage operation.
3. To determine how tires and tracks transmit forces to the soil in developing traction and in providing flotation for transport.
4. To develop mathematical methods which can be used to predict the effect of various forces on the soil.
5. To develop tillage methods and systems of equipment which are compatible with conservation farming practices.

### Progress - USDA and Cooperative Programs

#### A. Improved Soil Working Tools

At the National Tillage Machinery Laboratory, Auburn, Alabama, the deformation of soil subjected to penetration by chisels and cones was measured, using marker pins. Markers were embedded in the soil in a known pattern and their positions determined after the soil was deformed by simple tools. An increase in soil-tool friction increased soil displacement in the direction of travel of the tool. A decrease of tip angle increased the angle of lateral soil displacement from the centerline of the tool. Increasing the width of tools increased the total soil displacement. The displacement of soil resulting from the passage of a tool could be expressed by a logarithmic expression. The specific resistance of the soil to deformation was used

as a soil parameter to predict the draft pi term of vertical chisels. The specific resistance incorporates properties of the tool which are not distinguished by the cone index. In a series of studies in which different size vertical chisels were used, the specific resistance predicted draft with the same degree of accuracy as the cone index. The depth at which penetrometers attain equilibrium with soil conditions is determined by a soil-tool interaction. The properties of the penetrometer can be adjusted to minimize the interaction.

The National Tillage Machinery Laboratory abrader was compared with a laboratory model Taber abrader on samples of three metals proposed for tillage tools. The tests did not show the same relative wear of material, for the two test procedures. Further studies will be made to compare these two methods to study wear of metals and plastics. An experimental ferric-copper alloy compounded by the Southern Research Institute showed the same friction-adhesion measurements as steel and less wear resistance than steel. The steel had a rockwell hardness of 91.4 R<sub>B</sub> and the ferric-copper alloy had a hardness of 34.3 R<sub>C</sub> and 38.4 R<sub>C</sub>.

The first phase of a study on powered soil-working tools at the National Tillage Machinery Laboratory was to design and construct test equipment for making appropriate measurements on rotary tillage tools. One unit has been completed and a series of tests made with single tines. A second unit, for a full complement of blades is partially complete, and tests are scheduled.

Cooperative tests at the National Tillage Machinery Laboratory with Lilliston Implement Company of Albany, Georgia, on various shapes of a 14-inch diameter slicer tine tiller wheel provided data for Lilliston engineers to redesign the tine to reduce the vertical force necessary for soil penetration. The new slicer tine design was a compromise of the shape that had a minimum vertical force and the shape that could be practically and economically manufactured. Tests were run in a Norfolk sandy loam soil to compare the vertical and draft forces on the new slicer tine with those on the original slicer tine. When run at 0 degrees vertical tilt angle, 25 degrees horizontal approach angle, and at 5 m.p.h., the vertical force on the new slicer tine was 60 lbs., which was 40 percent lower than the vertical force on the original slicer tine. The draft force on the two tines was the same. Lilliston is using the new slicer tine on their rolling cultivator.

A cooperative project at the National Tillage Machinery Laboratory with International Harvester Company, Hinsdale, Illinois, was extended to include larger bulldozer blades and more soil conditions. Similitude studies were conducted in four soils and seven soil conditions with seven sizes of blades. Similarity was measured with respect to distance required for blades to obtain full load at various speeds and various depths of operation. With special techniques of distorted model theory, draft can be accurately predicted as a function of length scale only. Accuracy of prediction was independent of operation and velocity pi terms, and soil or

soil condition. A technique was developed for using a compensated model to study distorted soil-chisel systems. The model system was successfully compensated by distorting one operational pi term. Equations predicting draft of cultivator sweeps were developed using similitude. Equations considered soil strength, operating speed, vertical approach angle and angle between wings of sweep. A technique was developed to account for distortion in certain soil-tool systems. If model and prototype are operated in the same soil condition, distortion is a function of length scale only and soil parameters need not be defined or measured. If at least two soil parameters with different dimensions are pertinent to the system, it is distorted. This technique is valid for all passive tool-soil systems.

Engineers at the National Tillage Machinery Laboratory designed and constructed a hand operated penetrometer, with an integral battery-powered recorder for measurements of penetration force versus depth of penetration. Tests have shown this instrument to be a practical unit for field use.

#### B. Tillage Systems for Improved Plant Growth

Research in cooperation with the Alabama Agricultural Experiment Station showed that there was a significant difference in the 1967 growing season between plowing 6 inches deep and harrowing and subsoiling 18 inches deep. The cotton yields were 1608 lbs. of seed cotton and 2018 lbs. of seed cotton per acre, respectively. However, detailed sampling of pH in the subsoil showed that the lime had not been mixed well in the subsoil. Due to an early freeze in North Alabama, the plots tilled to 18 inches deep under the row were not harvested. In South Alabama there was a 15 percent decrease in cotton yield on Augusta fine sandy loam and a 30 percent increase yield on Chesterfield loamy sand on plots tilled 18 inches deep, as compared to plots plowed six inches deep.

A controlled traffic experiment was initiated on the Auburn University Agricultural Engineering Research Unit, but it was not possible to space the wheels away from the cotton rows as much as was desired. In spite of this, the cotton yield was 2964 lbs. of seed cotton per acre which was the highest yield on the Agricultural Engineering Research Unit this year. In cooperation with Deere and Company, equipment is being obtained to allow a wider wheel spacing for the 1968 crop season.

At the National Tillage Machinery Laboratory in Auburn, Alabama, root system development of an okra leaf cotton grown in ideal climatic and soil situations was observed, measured, and correlated with its physiological stages of aerial activities. Again this year daily measurements of root elongation, duration of growth period, and root life were recorded for roots and rootlets during the expanding and established root system stages of development. The weight of tap root, secondary roots, and rootlets were each determined by six-inch horizons to a depth of six feet after harvesting the crop. All data on okra leaf cotton roots were similar to earlier results using Alabama production cotton varieties.

A hard soil layer capable of preventing root penetration was created at plow depth in the Congaree silty loam bin. A portion of the bin was then subsoiled to a depth of 24 inches with a four-inch wide subsoiler and the rest was subsoiled to a similar depth with an 11-inch wide subsoiler. Both subsoiled plots underwent a surface traffic treatment at various distances (directly over to 20 inches) on each side of the subsoiled slots. Cotton was planted directly over the subsoiler slots and germination counts, growth measurements, and cotton yields were determined for each treatment. Soil strength, denseness, oxygen concentration, and root proliferation were also correlated with the treatments.

Research at Ames, Iowa, in cooperation with the Iowa Agricultural Experiment Station, using 30-inch spacing of corn rows, indicated that applications of Atrazine and Simazine were successful substitutes for plowing. Secondary tillage operations added little to corn yields when weeds were controlled and adequate stands were obtained. Strip-rotary tillage resulted in more consistent and uniform stands than other secondary tillage systems. These studies indicate that corn can be produced without tillage but some tillage is necessary to obtain satisfactory stands. Tillage system evaluations where weeds were controlled chemically show that stand establishment is the major problem. Results from 1964-1967 studies on tillage systems show that listing, no tillage, and till-planting result in fewer plants and less stand uniformity than the other systems. Evaluations of rotary and conventional tillage systems on the basis of inputs (time, fuel, labor and machinery costs) and outputs (corn yield) with restrictions on weather, acreage, and timeliness indicate a greater return per unit of investment with corn acreage above 500. Model studies of vibrating tools show some draft reduction but no reduction in total energy input. Soil clod size distribution was controlled by controlling amplitude and frequency of tillage tool vibration. Combinations of standard deviations and spectral density analysis of point elevation readings show promise as a method of describing soil surface roughness. Results from continuous corn and soybeans grown on 30-inch ridges indicate the need for design changes in planter and fertilizer application equipment.

#### C. Improved Traction and Transport Devices

At the National Tillage Machinery Laboratory, two tires, size 18.4 x 34, with 6 ply rating, which were very similar except for lug angle were compared in several soils and on concrete. One tire had a 45° lug angle, the other was 62°; both had 22 lugs. No significant difference could be detected in the pull or the tractive power efficiency of these two tires. Equipment modifications have been made for tests of a pneumatic track, and for tests of paddy wheels of the type used on rice field powered tillers. Qualitative evaluation was made of an experimental half-track made by Sidewinder Corporation of Minden, Louisiana. This track has locking track shoes which result in a rigid straight track in contact with the ground.

Also at the National Tillage Machinery Laboratory strain-controlled triaxial tests were conducted on two artificial soils previously used in stress-controlled tests. Results fit the compaction surface on the three-dimensional yield diagram obtained earlier. Stress-strain curves were also obtained using different strain calculations. A method of calculating strain was devised in which the strain caused by the volume change was not included in the strain calculation. Evaluation of these stress-strain relationships is continuing.

Engineers at the National Tillage Machinery Laboratory designed and constructed a special purpose analog computer for calculating the slip of powered wheels. The unit has been tested and is presently being used for traction studies.

#### D. Foreign Research Under Public Law 480 Funds

1. At the Institute of Agricultural Mechanization and Electrification, Warsaw, Poland, an investigation was begun on energy requirements for tillage by combining active and passive soil-working tools. Initial tests were begun in the laboratory in a 2 m. wide by 20 m. long soil bin using a moderately cohesive soil and full scale tools. A self-propelled, electric motor driven carriage was developed to carry and provide power for active (rotary) and passive (plow, sweep or chisel type) soil working tools and to measure three-dimensional forces and torque requirements of soil tools under test. Measurements of forces and moments have been completed on one set of rotary cultivator blades operating at four depths (6-15 cm) four forward speeds (.47-1.72m/sec) and four lengths of bite (forward travel per cut) (4-10 cm). A measuring device for forces on a passive working element (duck foot) is being made. With it measurements will be made on the passive tool alone and in combination with the rotary cultivator.

2. Research has been completed at the University of Bologna, Italy, on development of methods and equipment for breaking up cohesive clay soils into small clod sizes for deep tillage.

a. A theory of soil resistance to cutting with a wire was developed, which indicates that from the funicular curve obtained experimentally with a cutting wire it is possible to determine the variation of the soil reactions on the wire. The theory was applied in different soil in a specially constructed soil container with special measurement devices.

b. From laboratory experiments with five models of implements (mold-board plow, special subsoilers, knife-coulter, disc-coulter) in translatory movement it was ascertained that oscillations reduce the tractive effort of the implement models, but in general there is a particular type of oscillation for each type of implement, that produces a maximum reduction of tractive effort: for example, the double oscillation for the special subsoiler and for knife-coulter (reduction ranging

about 20 percent for the former, 25 percent for the latter); the transversal oscillation for the moldboard plow (reduction ranging up to 28 percent).

This reduction furthermore is also a function of soil moisture and degree of compaction.

c. Field experiments were carried out with five moldboard plows (depth from 25 to 95 cm), three rotary tillers (depth from 30 to 50 cm), and one experimental subsoiler. Degree of tillage was determined by classifying clod size distributions according to weight and was described by a coarseness index. Correlations between type of implement, energy requirements, and degree of soil breaking were studied and results summarized for different soil conditions. It was concluded that more deep tillage was desirable, but that it would not be economically feasible to accomplish the same degree of soil break up throughout the entire tilled layer.

3. Work was continued on a three-year research project by the Volcani Institute of Agricultural Research at Rehovot, Israel, on the influence of tillage operations on soil physical conditions related to crop growth.

a. Dryland farming experiment: The experiment at Revadim is being continued concurrently in three fields, to study the sequential effect of tillage treatments on the three-year crop rotation.

b. Irrigated farming experiment: The experiment at Gan Shmuel is being continued in the same field and the same treatments have been repeated so as to evaluate the residual and cumulative effects of different tillage systems on soil conditions and crop response.

c. Auxiliary experiments: Laboratory and field tests are being held to seek a more fundamental understanding of soil structure - tillage interactions, particularly in grumusols. The performances of various soil testing devices and various soil indexes are being compared in relation to soil moisture, compaction and draft.

4. Research has been initiated at the Indian Institute of Technology, Kharagpur, India, on soil reactions to traction forces. Availability of necessary instrumentation was investigated and equipment ordered. An indoor soil bin 60 feet long by 4 feet wide by 2 feet deep has been designed and is being constructed. A cable-drawn rail-mounted trolley with lateral as well as lengthwise travel is to be provided for use over the bin to carry soil preparation equipment and for mounting wheels under test. An existing, smaller soil bin is being modified and equipped for initial tests until the larger bin is ready. The initial tests in lateritic, native soils will be to measure traction and slip of traction wheels under different soil moisture conditions including a flooded condition; and to determine factors contributing to tractive effort and rolling resistance of traction wheels.

Publications, USDA and Cooperative Programs

Improved Soil Working Tools

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TROUSE, A.C. Effects of Soil Compression on the Development of Sugar-cane Roots. Proc. 12th Congress of the International Society of Sugar-Cane Technologists, Santurce, Puerto Rico, 1965. Published by Elsevier Publishing Co., Amsterdam. 1967.

Improved Traction and Transport Devices

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RANGE MANAGEMENT

RPA 112

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
New Mexico (University Park)	Grass seeding and brush eradication	Contract
Texas (Bushland)	Grass seeding and brush eradication	1.0
Total		1.0

Intramural program is supplemented by extramural support representing

(a) 0.5 SMY's at State Agricultural Experiment Stations, (b) 0.0 SMY's at other U.S. institutions.

### Problems and Objectives

More than 200 million acres of grazing land in Southwestern United States have become infested with brush, with a corresponding reduction in grazing potential. Many of these rangeland areas with high forage potential now provide little or no effective grazing for livestock because of dense brush infestation. As rangeland brush problems increase, basic stands of native grasses undergo progressive decline, because of increased grazing pressure with a resulting intensification of soil and water conservation problems, and reduced livestock production from the land areas affected. The general public, as well as the rancher, is concerned with grassland restoration, since the brush species materially reduce sod cover and accentuate wind and water erosion, thereby reducing the yield and quality of water and value of our land resources.

Major research objectives are:

1. To develop methods and equipment for reducing brush cover on rangeland.
2. To determine the environment required for emergence and growth of grass seedlings.
3. To develop methods and equipment for seeding grasses on rough rangeland.

### Progress - USDA and Cooperative Programs

Five special machines designed and constructed by AERD were used to seed range grasses in cooperative field experiments at eleven different locations in North Central Texas. Four of six herbicides gave satisfactory control of competitive plants in the establishment of a number of the ten species tested. Both broad leaf weeds and annual grasses were checked by atrazine, CP 50144, diuron and tritac (all at 1 1/2 lbs./A). Four species tolerated the first herbicide -- three species the next two chemicals. (Jose tall wheat grass and sand bluestem were in both groups.) In the range grass studies in the Canadian River Valley, only two or nine species were able to get satisfactory establishment (Ermelo lovegrass and blue panic). In the application of nitrogen fertilizer to native range grasses in the same area, production from treatments with 50 lbs. N/A subsurface were equal to 200 lbs. N/A broadcast.

Contract research with the New Mexico Agricultural Experiment Station on range seeding equipment was concluded and the project closed.

Five acre test plantings were seeded in June 1967 at five southwestern U.S. locations with equipment previously developed on the project. This tractor-mounted and drawn equipment uproots undesirable brush, seeds desirable range grasses, and repositions the uprooted brush on the seeded strip.

The equipment modification under test was a redesigned, overhead conveyor for handling the brush. Three additional plantings were made in July after further remodeling of the equipment.

The remodeled equipment functioned satisfactorily and accomplished the desired objective. However, it is heavy and awkward to maneuver. It will have to be redesigned to make it commercially acceptable, but such a combined conveyor-planter could have wide application in southwestern range land. The resulting stands of range grasses are to be evaluated later.

Publications - USDA and Cooperative Programs

None

CONTROL OF INSECT PESTS OF FRUIT AND VEGETABLE CROPS

RPA 204

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Arizona (Tucson)	Vegetables	1.0
California (Riverside)	Vegetables	1.0
Georgia (Albany)	Pecans	-
Indiana (Lafayette)	Peaches	Grant
Indiana (Lafayette)	Vegetables	0.5
Maryland (Beltsville)	Spray studies	1.1
Mississippi (State College)	Spray studies	Contract
Ohio (Wooster)	Vegetables	1.6
Oregon (Forest Grove)	Spray studies	0.8
Oregon (Forest Grove)	Vegetables	0.2
Washington (Yakima)	Apples	2.0
	Total	8.2
Israel (Rehovot)	Spray studies	PL-480

Intramural program is supplemented by extramural support representing (a) 2.6 SMY's at State Agricultural Experiment Stations, (b) 0.0 SMY's at other U.S. institutions and (c) PL-480 funds in one country representing \$14,700 U.S. dollars equivalent.

### Problems and Objectives

Successful commercial production of most fruit and vegetable crops requires expensive inputs to control the ravages of insect pests. Chemical pesticides have provided a defensive method for growers to obtain control, but many chemicals have gradually lost their effectiveness as the insect populations developed resistance or tolerance. This situation and increasing concern about pesticide residues on food items and in the general environment indicate that research should be directed toward reducing the amount of toxic material applied and toward replacement of chemical control with other methods of repelling or destroying insect pests.

Engineering objectives of the research program are:

1. To improve deposition efficiency of chemical sprays, thereby reducing the total amount of toxic material applied.
2. To improve non-spray methods of applying chemicals.
3. To determine the influence of electromagnetic radiation of all wavelengths on repelling or attracting insects.
4. To develop electric equipment for attracting and destroying insect pests.

### Progress - USDA and Cooperative Programs

#### A. Spray Studies

At Beltsville, Maryland, engineers developed an electrostatic boom for use on a Cessna 180 plane to include 1065 tube openings .0135 inches in diameter and a copper charge bar 1-1/2 inches from the tubes. When spraying at 40 lb. psi, the static charge of 25 KV did not influence the discharge rate.

A screw-worm box ejector was modified and over one million sterile Drosophila flies were released from an airplane for native fly control on tomatoes. Information was gained for a more suitable fly ejector device.

A reduction in labor in the removal of tops and suckers from tobacco plants may be possible with foam inhibitors. From a series of foaming solutions tested, three appear promising as carriers of growth inhibitors. In laboratory tests, C10 alcohol controlled flowering and sucker growth on tobacco plants.

Contract research at State College, Mississippi, has shown that trajectories of particles released from an aircraft show wingtip vortices exert significant influence only on the path of small particles less than 500 micron diameter. This is true when aircraft altitude is at a minimum safe flight, and provided the particles are released at a point on the wing outside the core region of the tip vortex. A computer program is being modified to

compare experimental trajectory and theoretical wingtip vortex data to develop empirical relationships. This will provide an easier rapid method of particle trajectory for deposition on crops. A wind tunnel was developed for studying the dynamics of liquid droplets in flight.

A theoretical analysis in mechanics of solid materials dispersed from aircraft by pneumatic spreaders yielded two sets of equations. The equations are being verified by simulated tests. Valid equations will provide a means for a more effective design of applicators.

Helicopter spray systems for virus and carrier solutions were developed at Forest Grove, Oregon, and tested on Douglas Fir-Tussock moth larvae. Drop-let sizes were 106 and 230 microns mmd. Twenty-one-day bioassays on sprayed forest trees gave about 50 percent mortality, reaching 95 percent mortal-ities after 50 days. Helicopter releases of boxed sterile codling moths gave seasonal control of apple damage equal to normal spray programs at Yakima, Washington. Sterile to wild male ratio was 62:1 for releases over a 90-acre orchard between May and September.

A viscous materials pump has been developed for lure-toxicants for fruit flies. Tests will be run in Hawaii with equipment designed to fit leased Cessna aircraft.

A motor has been bench-tested and found suitable for the Bals spinning nozzle. Field tests are needed to determine the life of the unit.

A preventive spray program using helicopters on broccoli was tried for the second year against cabbage looper. Selected chemicals were applied on a ten-day program using ten and 15 gpa sprays. Chemicals used were DDT ester, parathion, phosdrin and TEPP. After seven treatments between August 9 and October 2, inspection of harvest at processing plant showed no damage to the crop, showing the success of the planned treatment.

## B. Apples

At Yakima, Washington, the task of separating codling moth pupae, male from female, by size differences was improved with a machine modified to make 10 separate divisions. Using male insects separately is more effective than mixed sex in the sterile release program for controlling native infestations. Reflectance of codling moth pupa was greater in the infra-red wave length (1.1 nanometers) than shorter wave lengths for separating only mature pupa. Only by using mature pupae when sterilized by irradia-tion can optimum vigor be maintained.

A flight mill was developed as a research tool to record flight time and distance for determining flight vigor of insects treated or reared dif-ferently. An insect trap suitable for use in remote areas without electric power was developed to collect insects in separate containers hourly for 28 hours without service. This provides a means of monitoring insect flight habits, population trends and species for efficient effective

control measures. Green peach aphid flight last season was mainly early and late daylight hours. Maximum flights were in May and August into September. Over 40 identified insect species were caught in the trap. An experimental pump and cone disc dispenser developed for ULV application produced seven to eight times more chemical (59 percent of the material) lay down eight inches above the row compared to a pressure nozzle using low or high liquid flow rate.

Tests of response of caged codling moths to blacklight ultra-violet radiation indicated over 50 percent attraction the first night and 70 percent or more the second night. Studies of the effect of light on diapause were initiated but results were inconclusive.

#### C. Peaches

Grant-supported research at Lafayette, Indiana, included tests of aphid locomotory responses to electromagnetic radiation from 350 nm wavelength to 700 nm, using a small, 12 inch x 3 inch, pentagonal test arena. Adult apterous aphids exhibited a gradual decrease in response to a monochromatic diffused light source as wavelength increased. When apterous and alate aphids were given a choice between diffused monochromatic light and diffused "white" light from a clear tungsten lamp, a sudden reversal of preference from monochromatic light to "white" light occurred for wavelengths of 600 nm and longer. This appears to agree with general observations that orange is attractive to aphids. In further tests infrared was filtered from the tungsten energy and no difference in response was noted between tests with, or without infrared energy. Similar tests were made using wavelengths from 450 nm to 600 nm with aphids of different ages, including first-instar nymphs and seven age groups of adult apterae from one to nineteen days after final molt. No significant differences were apparent in the adults, but the nymphs were more responsive than adults at each wavelength.

#### D. Pecans

A light-trap experiment was begun at Albany, Georgia, in an isolated eight-acre pecan grove using 33 traps with single 15-watt BL lamps. Hickory shuckworms were the only important pecan insects captured. Monitor traps outside the orchard on all four sides caught only 59 shuckworm moths, indicating no migration. Shuckworm infestation in shucks averaged only 14.6 percent in the lighted grove with a nut crop average over 50 lbs/tree. Flight activity of female shuckworm moths was found to be greatest about one hour after sunset, with male flight increasing rapidly at the same time but continuing at a high level two to three hours longer.

#### E. Vegetables

A field trial of blacklight insect traps baited with sex pheromone of the cabbage looper, Trichoplusia ni (Hubner), was begun on a lettuce-producing

ranch near Red Rock, Arizona. The ranch includes 2240 tillable acres divided into nominal 80-acre fields. A total of 415 trap locations are spaced at 330 feet intervals around the perimeters of these fields. An unlighted check area is located eight miles away near Picacho, Arizona. Trap collections, larval counts and egg counts of cabbage loopers, cotton bollworms, salt marsh caterpillars and beet armyworms are being analyzed to evaluate the degree of insect control achieved. Trapping began in February 1967. During the first season equipment functioned satisfactorily and unexpectedly large numbers of insects were caught. Ratios of male catches to female catches for the cabbage looper were high in both locations, indicating influence of the pheromone, but ratios of males to females were higher at Picacho than at Red Rock during population peaks. The grower applied usual amounts of insecticides in both areas and insect populations remained low. Additional data must be accumulated for adequate evaluation.

Tests of screen-cage traps, electrocutor grid traps, and light traps at Riverside, California, indicated that light is not essential to catch large numbers of male cabbage loopers in traps baited with synthetic sex pheromone. Traps using only the sex pheromone as an attractant catch almost exclusively male cabbage loopers, which simplifies counting and identification in survey-type applications. Catches of male loopers in screen traps were similar to catches in light traps baited with pheromone. Electrocutor grids also proved effective as killing devices for pheromone traps. Selection of a proper basis for comparing such different devices is difficult.

Two improved pheromone dispensers were developed: One uses a wick in a reservoir and remains attractive for three months; in the other the pheromone is sealed in a polyethylene bag and diffuses through the walls. The bag initially is as attractive as any other dispenser but attractiveness decreases with time, similar to jars with sand used last year. Caged male cabbage loopers responded to the pheromone at least 300 feet downwind from the pheromone source. Tests with traps at various densities indicated the need for evaluating interaction effects on trap catches in large areas. Increasing the density of traps does not proportionately increase the number of insects caught.

Use of light traps alone and of light traps plus insecticide has been compared at Lafayette, Indiana, for two years for protection of short-season hybrid cucumbers grown for pickling. Results show no real differences in insect damage, beetle population, yield, or incidence of bacterial wilt within 700 feet of light traps. Interpretation could be that light traps are as effective as insecticides; however, combined effects of cultural practices, varieties grown and environmental factors really eliminate need for beetle control, except under optimum conditions for insect multiplication.

Blacklight traps are being effectively used for population surveys of sod webworms (various Crambus sp) and show some promise for control. Investigations were begun of possible use of electric grids with dusk-to-dawn

security lights for killing insects. Insect attraction is directly related to ultraviolet output from the lamps and their refractors. Clear, color-improved white, and deluxe-white 175-watt G.E. mercury-vapor lamps proved equally attractive to insects. At 20-foot lamp elevations insects tended to become windborne and could not direct themselves to the lamps at wind velocities above three to five miles per hour.

Engineers studying ultra low volume application of insecticides at Wooster, Ohio, used an outside mixing air nozzle with increased air flow modification to apply Guthion ULV, Cygon 2E, Meta-Systox-R ULV and Malathion ULV at dosages of 6 to 24 avdp. oz. per acre. The same insecticides were applied in hydraulic spray at 150 gal. per acre. Meta-Systox-R controlled turnip aphid and green peach aphid on peppers and potato aphid and two-spotted spider mite on eggplant when applied by both types of equipment. Control of insects by other materials on 10 vegetables treated was not obtained by either type application equipment. Study of physical properties vs. temperature shows flow rate can vary 5 to 19 percent with 5° F change in temperature of some ULV insecticides. Wettable powders added to spray formulation at 66 times normal concentration increased volume 10 percent. Violent hydraulic agitation increased some temperatures 10° F and volume 25 percent in five minutes. Normal, 33X, and 66X sprays were applied to randomized plots of Red Rome Beauty and Cortland apple trees averaging 17 feet in height. Scab and insect control was satisfactory in all plots. Data on control of European red mite was inconclusive.

In tests with trailing boom sprayer at Aurora, Oregon, mixed dusts bridged in the hopper where individual dusts flowed readily. Mechanical agitation mounted on the hopper lid overcame this problem. A vertical rotating shaft with piano wire spines inserted broke up the lodged dust. Gate agitation and compressed air fluidizing was insufficient.

#### F. Foreign Research Under Public Law 480 Funds

Engineers studied the application of air jets with a vortex to improve penetration of air-borne insecticide sprays into dense foliage of citrus trees at the Volcani Institute of Agricultural Research, Rehovot, Israel. Tests showed no more energy is needed with the vortex air stream or swirling jet sprayer developed than with a regular, flat airstream sprayer for the same mean spray penetration into a tree. Significant differences were found in volume of spray in some parts of tree. The performance characteristics of the sprayer as modified were determined. A formula was developed for describing the droplet size range with different sprayer capacities and pressures. Tests were made with 200, 275, and 400 micron nominal size droplets. The effect of droplet size on spray penetration into the tree was highly significant with regular air-blast sprayers. Smaller size gave poor recovery and larger size gave poor penetration. The intermediate size gave fair distribution. Comparisons between regular air-blast and swirl jet sprayers were made with intermediate size droplets. The distribution with the swirl jet was a little more uniform from outside to inside of tree, but the settling at top and bottom of tree was much poorer.

Publications - USDA and Cooperative Programs

Spray Studies

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CONTROL OF INSECT PESTS OF FIELD CROPS  
(RPA 207)

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Florida (Gainesville)	Attraction Studies	0.5
Georgia (Atlanta)	Attraction Studies	Coop. Agreement
Michigan (Ann Arbor)	Attraction Studies	Contract
Georgia (Tifton)	Corn and Cotton	1.0
Iowa (Ames)	Corn	0.3
Ohio (Wooster)	Corn	0.4
Mississippi (State College)	Cotton	1.0
South Carolina (Florence)	Cotton	1.0
Texas (College Station)	Cotton	1.5
Florida (Quincy)	Tobacco	0.0
North Carolina (Oxford)	Tobacco	1.0
Virginia (Blacksburg)	Tobacco	1.0
Virgin Islands (St. Croix)	Tobacco	1.0
Nebraska (Lincoln)	Stored Grain	0.5
	Total	9.2

Intramural program is supplemented by extramural support representing 3.5  
SMY's at other U.S. institutions.

## Problems and Objectives

The economic loss of field crops from insect damage was estimated at \$19 billion in 1964 despite the effects of insect-control programs. To reduce this loss, in the face of increasing difficulty in controlling insects as they become resistant to insecticides and increasing concern about chemical residues in the environment, it is essential that existing chemical materials be applied most effectively and that nonchemical control methods be thoroughly evaluated.

Engineering objectives of the research program include:

1. Development and evaluation of improved methods for applying insecticides.
2. Devising electrical methods and equipment for insect control.
3. Devising mechanical methods and equipment for direct insect control or for rendering host-plant material unfit for insects.
4. Evaluating uses of control principles in combination.

## Progress - USDA and Cooperative Programs

### A. Attraction Studies

1. Corn insect response to infrared. In preparation for staffing the Insect Attractants Laboratory at Gainesville, Florida, a professional was hired and temporarily stationed at the Iowa Agricultural Experiment Station. There he pursued findings of others that the carbon dioxide ( $CO_2$ ) production of an insect may be used as an indicator of response to different stimuli. Laboratory equipment and instruments have been assembled for measuring the  $CO_2$  output of European corn borer adults while subjected to selected wavelength bands of radiation between 0.25 and 15 microns. Basic components are an infrared  $CO_2$  analyzer and a monochromator. Air, free of  $CO_2$ , is passed through the insect chamber to the  $CO_2$  analyzer and exhausted. Preliminary experiments revealed patterns of behavior for single insects, showing suppression of activity by light and a maximum activity in darkness from 4 a.m. to 8 a.m. Suppression of activity by light varies with age of insect and time of day. During the dark nights, the characteristic night activity persists regardless of previous handling and exposure to light. Activity may last 10 minutes and resume after less than 1 minute of rest.  $CO_2$  output from inactive insects fluctuates very little; however, this output varies with temperature and other factors. Output of an active insect may be 20 times greater than that of an inactive insect. Outputs have ranged from 0.025 to 0.5 cc/hr/insect. A change of about 0.005 cc/hr. can be detected. The apparatus allows application of radiation to the insects in wide bands, using optical filters, or in narrow bands. Other stimuli, such as sound or a sex pheromone, can be introduced.

2. Skeletal detectors of infrared. In research under Cooperative Agreement with the Georgia Institute of Technology the possibility that insect spines detect infrared radiation was studied. Effort was concentrated in two separate areas, development of suitable methods and techniques for determining the dielectric constant of the insect exoskeleton at microwave frequencies of 70 and 90 GHz, and the development and construction of a far-infrared gas laser to provide coherent radiation for behavioral tests of the response of insects to far-infrared radiation. Methods explored for dielectric constant measurement included waveguide bridge techniques and shorted waveguide techniques, as well as use of a far-infrared interferometer. Reliability of the methods was checked, using materials of known dielectric constant. Measurements on pellets compressed in specially constructed waveguide test cells from powdered hornworm exoskeletons have, through density-dielectric constant relationships, established approximate values for the dielectric constant of the integral exoskeleton. Construction of the far-infrared gas laser has progressed to the point where several far-infrared lines have been identified in the laser output. Laser operation has been achieved with water vapor, a mixture of methane and nitrogen, and a mixture of water vapor and acetonitrile. Coherent radiation has been identified at 78- and 337-micron wavelengths. This work is providing information which will help to determine whether or not insects utilize infrared radiation in their communication processes.

3. General responses to infrared. General insect responses to infrared radiation are the subject of contract research conducted by the University of Michigan. Species studied are: Heliothis zea, corn earworm; Spodotera frugiperda, fall armyworm, and Plodia interpunctella, Indian-meal moth.

In behavioral studies no responses of insects to infrared radiation have yet been observed nor have any infrared output signals between 2 and 20 microns from insects been measured. Attraction to blacklight radiation, to currents of moist air, and to odor from female insects has been observed. Measurement of the rate of evolution of carbon dioxide from insects has been confirmed as an effective means for remotely evaluating stimulation of the insects. Active, or internally stimulated, insects evolve more CO<sub>2</sub> and cyclic patterns are evident. Measurements of the characteristics of physiological tissue indicate infrared transmission of the corneas of all three species of moths are essentially the same in the region of 1-15 microns. Transmission of antennae and sections of exoskeleton are similar to the corneas. Attempts to detect nerve signals from antennae in response to irradiation were unsuccessful, but manipulation produced signals. The sudden creation of a static electric field of 75 v. per cm. near earworm moths caused no change in behavior nor orientation to the field.

#### B. Corn

1. Georgia. Research at the Southern Grain Insects Research Laboratory, Tifton, Georgia, determined that the addition of an air stream for a pesticide carrier on ultra-low-volume (ULV) pressure spray nozzle equipment improved

Insect control on sweet corn when light infestations occurred. One pint of malathion per acre was as effective as a 2-lb. application of DDT using conventional equipment.

The use of an electrostatic charge on ULV pesticide spray or dust did not improve insect control on sweet corn.

Boll weevil was controlled as effectively on small cotton plants using ULV spray equipment with narrow angle spray nozzles as with conventional spray equipment using large volumes of spray. Chemical defoliant applied on cotton was effective in removing leaves using ULV equipment but took longer than when applied with more water using conventional sprayers.

Equipment to mechanize removal of fall armyworms from containers in the mass rearing operations was improved and effective. Oviposition cages were improved materially in reducing labor for the corn earworm pupae-rearing operations. Removal of small insect scale buildup in cages was not completely solved.

2. Iowa. In cooperative work at the Iowa Station, including ENT Division, first-brood borer control was not improved when rate of application of DDT or diazinon was increased to compensate for different row spacings and plant populations. These preliminary results indicate that available granular application equipment and techniques are adequate for acceptable borer control where narrow rows and high populations are used. Systemic insecticides for corn borer control continue to show promise. Chemicals placed 10" to side of the corn plant 2-4" deep with a mechanical cultivation gave better control than applications at planting time with seed, 2" to side of seed, with starter fertilizer, or 2" to side and 2" below the seed. Diazinon granular applications caused slight to moderate amounts of phytotoxicity on 45 single-cross corn varieties and 20 inbred lines. This phytotoxicity had little or no effect on yield. Changes in application equipment and techniques for applying diazinon granules are not indicated. Both liquid and granular formulations of Bacillus thuringiensis gave excellent control of first-brood borers. Some liquid formulations tested would not stay in suspension and could not be applied as sprays. Some granular formulations were inadequately sized and could not be metered accurately. Either formulations must be improved or equipment must be redesigned for acceptable Bacillus applications. Covering diazinon granules with 1, 2, or 3" of soil at cultivating time did not improve corn rootworm control over surface applications. Similar studies in previous years have shown that some soil coverage is beneficial but depth is not important.

3. Ohio. At the Ohio Agricultural Research and Development Center in cooperative studies with ENT Division, a granular insecticide was incorporated to various depths by several types of tools. Best yields were obtained from surface incorporation by a scraper blade tool. Several granular insecticides were surface incorporated in a 6-inch width over the planter row by the scraper blade tool. Yield, root rating, and reduction of rootworm larvae population were significantly improved in Furadan-10g and Aldrin-20g treatments.

Liquid sprays of Baygon, carbaryl, diazinon, and malathion applied to the ear zone for control of adult northern corn rootworm each reduced population by at least 96 percent. Yields were significantly increased in each treatment compared to an untreated plot.

Corn leaf aphids were controlled by a spray of 57 percent malathion EC applied either over the row or from the sides of the row.

Laboratory study of granular applicators shows considerable linear variation in amounts of material distributed down the row even though total flow over a timed period may indicate the feed rate is uniform.

#### C. Cotton

1. Mechanical equipment. At the Boll Weevil Research Laboratory, State College, Mississippi, destroying boll weevil in fallen cotton squares with a flail-type machine was effective. In basic machine design studies, the efficiency in collecting fallen squares was 93.5 percent, or 5 percent more with this year's design changes. The design of ground brushes, air exit opening, machine and ground speed all influence machine efficiency.

A narrow-spectrum droplet generator was developed and tested to evaluate 140-, 200-, and 300-micron diameter droplets on insect control and spray deposit. No significant differences in control of boll weevil, or oviposition punctures, were found due to droplet size. Neither were the controlled droplet size treatments significantly different from the standard ULV applications.

2. Sound. Field and laboratory tests, in cooperation with the South Carolina Pee Dee Station and the ENT Division, revealed that bollworm moths (H. zea) detect continuous as well as intermittent ultrasound, but that behavioral responses are elicited only by intermittent ultrasound. Greatest effect on behavior was produced by 10-millisecond pulses of 20- to 30-KHz ultrasound stimuli at pulse rates of 10 to 75 pulses per second. An arcing electric grid was found to emit ultrasonic energy within the frequency and pulse range known to repel the moths or elicit evasive responses. Sound level output from the grid was 130 dB at 3 feet. Results of efforts to evaluate repellent effects of the electric grid discharge on bollworm catches in a light trap, however, were inconclusive.

Field tests indicated there was no measurable repellent effect or change in flight activities of bollworm moths subjected to sound produced by an air whistle. The output of the air whistle was 116 dB at 10 feet and was a continuous sine wave with a frequency of 20 KHz. Acoustic sense-cell studies revealed that this signal could be detected by bollworm moths at a distance of 350 feet. Since pulsed sound stimuli are necessary to elicit behavioral responses in bollworm moths, a pulsing mechanism will be incorporated in the air whistle before further field studies are conducted. Further work is needed to determine basic information related to sound sources and insect receptors before significant progress can be made in beneficially utilizing sound as an insect-control method.

3. Electric insect traps. In cooperative work at the Texas Agricultural Experiment Station determinations of efficiency of light traps in catching insects validated procedures developed for such work in 1966. Such measurements will enable rapid delineation and evaluation of factors influencing trap efficiency so that appropriate design changes can be made. Trap design studies showed that length of attractant lamp and total ultraviolet emission exerted strong positive influences on trap catches of bollworm, cabbage looper, and tobacco budworm moths. Use of baffles and funnel diameters of 30" were found essential for maximizing catches. These findings contribute to information needed on trap design parameters.

Results of trials in Mexico indicate that traps with 15-watt blacklight fluorescent lamps, installed at a trap density of approximately one per acre, did not effectively reduce the influx of corn earworm moths in corn plantings. This emphasizes the need for significant improvements in trap design and/or trap-installation design.

Work with a security-type lighting fixture equipped with a 175-watt mercury vapor lamp showed that use of refractors that effectively eliminate ultraviolet radiation from the fixture emission will significantly reduce fixture attractiveness for most species of night-flying lepidopterous insects. This finding is significant to users of security-type lighting fixtures in areas where this lighting method creates problems with nuisance insects.

#### D. Tobacco

1. Shade-grown tobacco. An integrated insect-control program was tested that included insect light traps spaced at 150-foot intervals around the outside of canvas-covered tobacco fields, a systemic insecticide applied to the soil prior to transplanting, and nonpersistent insecticide treatment of the growing crop as needed. Damaged-plant data from eight other fields of tobacco that received one to two applications of insecticide weekly, considered to be a conventional program, indicated that the damage from tobacco budworms and cabbage loopers was 2.8 times greater than the plant damage in seven fields under the integrated control program. The integrated program reduced the amount of insecticide needed by a significant amount. Synthesized cabbage looper sex pheromone was incorporated with each of the 1,100 traps used in the program over the 400-square-mile shade-grown tobacco area. Cold weather reduced the insect activity after the test was started in the fall, but the results of the test were encouraging.

This work is cooperative with the ENT Division and the Florida Station, but at present AE Division has no professional participant.

2. Insect response studies. Related work is conducted with the Research Division of Virginia Polytechnic Institute, partially under Cooperative Agreement.

In laboratory studies on the attraction of insects by radiant energy, electro-physiological tests established the spectral sensitivity curve for the tobacco

hornworm moth. Response of the flight-muscle nerve is probably an indication of the moth's flight deviation in response to radiant energy. Response appeared greater to ultraviolet than to visible energy. Similar examinations of signals in optic nerves were made for responses to radiant energy. Limited electroretinographic studies were conducted on tobacco budworm moths, yielding a sensitivity curve similar to that of the hornworm moth.

In field studies, a combination of green and blacklight (BL) fluorescent lamps was less effective in attracting nocturnal tobacco insects than BL lamps alone. In experimental traps with three different-sized funnels nested together coaxially, it was found that the largest portion of the insects was collected in the central funnel, which was 18 inches in diameter. When uni-directional fan and gravity traps were operated under competitive conditions, gravity traps were more effective in trapping hornworm moths. In experiments comparing new and old lamps, no differences in catches were detected which could be attributed to lamp age. Neither were any differences detected between responses to BL lamps with two different types of phosphors. Major hornworm activity, as determined by light trap catches, was between 9 p.m. and 5 a.m., with the peak between 1 a.m. and 3 a.m.

Electrophysiological investigations with tobacco hornworm moths yielded no detectable evidence of response to sonic energy stimulations. Electrodes were placed in the cervical connective, antennal nerve, and Johnston's organ. Sonic treatments of 80-dB intensity ranged in frequency from 50 Hz to 100 KHz, pulsed at a rate of 10 pulses per second; and square-wave pulses, or "clicks," of 1-millisecond duration ranging from 1 to 100 pulses per second. Nerve responses were related more to elongation of an antenna than to deflection. Flight sounds of houseflies have been recorded and used as a stimulus, but no detectable response was obtained with flies.

3. Large-area trials. A large-scale field experiment on hornworm control is being conducted in cooperation with the North Carolina Station and the ENT Division.

In 1967, traps in the circular band of area between radii 5 and 10 miles from the area center were used to isolate the central 80-square-mile area in which sterile male tobacco hornworm moths were released to compete with native males. Although only 8,990 sterile males were released during the summer, tobacco hornworm moth populations, after the first brood, were lower inside than outside the release area by 56 and 52 percent, respectively, for males and females. Tomato hornworm moth populations were also lower inside than outside the release area by 25 and 12 percent, respectively, for males and females, indicating some residual effect from light traps during previous years but a population buildup when traps were removed. No major differences were measured for moth populations of tobacco budworm or corn earworm inside and outside the area in 1967.

In tests with caged moths, the threshold of response to a 15-watt blacklight source was between 91.4 and 121.9 meters from the energy source for tobacco hornworm moths and between 61.0 and 91.4 meters for the corn earworm moth.

Data collected in similar experiments in cooperation with ENT Division over a 22-month period on St. Croix indicate that using insect light traps with one 15-watt blacklight fluorescent lamp will reduce the population of Maduca sexta when installed at a density of approximately three traps per square mile. Additional data will help to determine whether these traps will control the population of this moth. Trap catches are greater during the dark period of the moon's cycle. Trap location appears to influence the catch. Weather factors also influence the catch. Equipment is being installed to monitor wind speed and direction, temperature, relative humidity, rainfall, and lunar illumination. These will be correlated with moth catches to determine their influence on moth activity. Various numbers and placement of lamps will be evaluated in improving trap efficiency.

E. Stored Grain - Nebraska Agricultural Experiment Station cooperating.

Radiofrequency (RF) electrical treatment of infested grain can control all developmental stages of all species of stored-grain insects tested thus far. Insect control can be achieved by treatments which do not damage wheat germination nor its milling and baking qualities, but costs of the electrical treatment are estimated to exceed those of chemical control methods. Therefore, studies are aimed at improving the efficiency of the RF control method. Work this year has dealt mainly with the development of methods for measuring the relative RF dielectric properties of insects and grain. These properties determine the relative absorption of energy from the RF electric field by insects and grain. Differences in the dielectric properties of the different materials determine the degree of selective absorption of energy by the insects as compared to grain. Since the dielectric properties of both vary with frequency, the measurement of the dielectric properties of insects and grain is necessary over a wide frequency range to discover the most effective frequencies to employ for insect control treatment of infested grain. Substantial progress was made this year in the development and improvement of methods for measuring dielectric properties in the following frequency ranges: 250 Hz to 20 KHz, 1 to 250 MHz, and 200 to 500 MHz. Some measurements were taken on adult rice weevils and on wheat samples, but analysis of results must await completion of methods development for reliable interpretation.

Publications - USDA and Cooperative Program

Corn

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Cotton

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Tobacco

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STEWART, P. A., GENTRY, C. R., KNOTT, C. M., and LAM, JR., J. J. Seasonal trends in catches of moths of the tobacco hornworm, tomato hornworm, and corn earworm in traps equipped with blacklight lamps in North Carolina. J. Econ. Entomol. 61(1):43-46. Feb. 1968.

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Stored Grain

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CONTROL OF WEEDS AND OTHER HAZARDS TO FIELD CROPS  
RPA 209

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Illinois (Urbana)	Soybeans	0.5
Iowa (Ames)	Corn, soybeans	0.7
Mississippi (Stoneville)	Cotton	1.0
Missouri (Columbia)	Corn, soybeans	1.0
Texas (College Station)	Drift studies	1.9
	Total	5.1
Israel (Beit Dagan)	Cutting roots and rhizomes	PL-480

Intramural program is supplemented by extramural support representing (a) 0.0 SMY's at State Agricultural Experiment Stations, (b) 0.0 SMY's at other U.S. institutions and (c) PL-480 funds in one country representing \$8,600 U.S. dollars equivalent.

### Problems and Objectives

Weeds in field crops increase production and harvesting costs, impede mechanization, and reduce yield and quality of crop products. The presence of particular weeds in a field may also limit the choice of crops to be planted.

The use of chemical herbicides has in many instances proven more effective than mechanical and cultural methods of weed control, and large acreages now receive one or more applications of chemicals each year. Low deposition efficiency wastes a high percentage of the chemicals used, and also increases the rate of build up of chemical residue in the soil. Drift of sprayed herbicide particles is frequently a hazard to adjacent crops.

Engineering objectives of current research are to:

1. Improve deposition efficiency of sprays.
2. Reduce drift of spray particles.
3. Evaluate non-spray methods of applying herbicidal chemicals, such as rollers and brushes, granules, foam, wax bars, and others.
4. Evaluate non-chemical weed control methods.

### Progress - USDA and Cooperative Programs

#### A. Corn

Soil incorporation of herbicides for weed control in corn showed little benefit in studies at Ames, Iowa. Preplant applications were more effective than postplant. All incorporating tools were equally effective.

Early weed control was better when Treflan was incorporated. This improved weed control was not reflected in increased yields. Harrowing after planting and shallow cultivations were not needed when timely cultivations with sweeps and disk hillers were used to control weeds in corn. The germination rate of seeds tended to be decreased when subjected to high intensity electrical fields. Analysis of soil and water samples from controlled runoff plots showed some loss of pesticides in both soil and water. Nontoxic forms of Ramrod and Diazinon were found within two weeks after application. Directional and overall applications of Atrazine and oil were equally effective and both gave excellent weed control in corn when followed by mechanical cultivations. Weeds were successfully controlled with combinations using multiple row spacings for corn where a roadway was left for tractor tires.

At Columbia, Missouri, directional spray equipment had no effect on weed control in corn with Lorox and Clobber. Leaf lifters reduced damage when corn was less than 12 in. high. Directional and overall applications of Atrazine and oil gave equally effective weed control in corn rows. Lack of control between rows with directional sprays caused yield reductions. Directional spray studies with DNBP show that application equipment had little or no effect on control; however, soybeans less than 6-8 inches tall were damaged. Surface applications of Sutan-D were equal to incorporation with a powered rotary cultivator or injected beneath a sweep, but corn damage occurred with sweep applications. The effectiveness of Amiben was not improved with incorporation. Preemergence herbicides showed improved weed control when followed by rotary hoeing at spike stage. Fan-type nozzles gave better weed control than air atomizing nozzles for 0.25 to 1.0 gpa applications of Amiben and trifluralin. Variations in trifluralin between individual granules was 3 percent with a random selection from a 5 percent product.

#### B. Cotton

At Stoneville, Mississippi equipment was designed and constructed that would apply herbicides as a foam. With this equipment a stream of high velocity air at 3/4 psi was mixed with a stream of liquid from a flat-fan spray nozzle at 40 psi and directed through rubberized pig hair to produce relatively drift-free foam. Laboratory tests show promise and this equipment will be field tested in the future. An experimental tractor mounted plot sprayer was designed and constructed for testing large numbers of postemergence chemicals for weed control in soybeans and cotton. Through the use of electrically operated solenoid valves, quick-detachable hoses, and a push-button control panel, chemicals can be changed and the sprayer thoroughly cleaned with water without moving from the tractor seat. Laboratory tests of this sprayer using water and dye showed that little or no contamination occurred while changing chemicals. Studies are underway to develop a sprayer that will deliver a uniform amount of liquid regardless of changes in field speed. Several types of hose pumps were tested, and results show that accurate metering at levels needed for herbicide applications were obtained. The liquid flow from these pumps is in the form of solid streams or large droplets and the flow rate in proportion to ground speed. To obtain adequate coverage, these solid streams and large droplets must be broken down into small droplets that can be separated into a spray pattern. Using atomizing air streams at the end of the hoses from the pump shows promise as one method of obtaining adequate spray patterns.

#### C. Soybeans

Studies at Ames, Iowa, with soybean herbicides showed little benefit from incorporation in the soil. Weeds were successfully controlled with combinations of herbicides and mechanical cultivations using multiple row spacings where a roadway was left for tractor tires.

At Columbia, Missouri, severe soybean stand reductions occurred when a disk or powered rotary cultivator was used to incorporate trifluralin. Shallow incorporation caused less soybean stand reduction and better weed control than deep incorporation. Analysis of soil core samples showed that a powered rotary cultivator distributed trifluralin in the top inch of soil and that disking placed most of the chemical at 1/2 the working depth of the tool in a non-uniform pattern.

Progress on the soybean weed control project at Urbana, Illinois, was limited to construction and equipping of new facilities.

#### D. Drift Studies

A low-speed wind tunnel was designed, developed and constructed at College Station, Texas, to study spray drift. Straight nonturbulent airflow was obtained with screens and a foam-type filter. Airflow velocities of 0 to 10 mph were obtained with a variability of  $\pm$  5 feet per minute. Spray droplets were generated with a spinning disk atomizer that was designed and constructed. With this generator uniform spray droplets that were 100 microns diameter or greater could be injected into the wind tunnel at terminal velocities. Preliminary studies indicate that a different droplet generator (perhaps a vibrating needle) will be needed for smaller droplets. Several sampling techniques for measuring droplet size, evaporation and drift within the wind tunnel have been developed. Using fixed photographic film sheets that will retain a smooth-edged impression of the water and dye droplets offers the greatest potential as a collecting method. Studies are underway to develop methods of accurately measuring these droplet impressions on film.

#### E. Foreign Research under Public Law 480

At the Volcani Institute for Agricultural Research, Beit Dagan, Israel, laboratory experiments were conducted with models to determine strength parameters of composite material and effect on resistance to cutting tool. Effects on shear parameters of soil types, moisture-density conditions, root density and distribution, and root fixity in soil were studied. Soil, reinforced with synthetic fibers, in a transparent box was used. Failure of a soil composite under action of a cutting tool was found to be first passive rupture of soil followed by rupture from shearing resistance of composite. In a reinforced cohesionless soil fibers act as a continuous medium in all directions in front of cutting tool and increase height of stress zone and forces acting on cutting tool. Root cutting can be achieved efficiently only when roots are fixed in soil. A compaction device to increase fixity of roots in soil, and simultaneous compaction and root cutting was suggested. So far only one blade angle has been studied and speeds of approach have not yielded significant results.

Publications - USDA and Cooperative Programs

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CONTROL OF DISEASES OF LIVESTOCK AND POULTRY  
(RPA 211)

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Georgia (Athens)	Broilers	1.2
Mississippi (State College)	Broilers	2.0
Minnesota (St. Paul)	Turkeys	1.0
	Total	4.2

### Problems and Objectives

Poultry diseases cause producers major economic losses through direct mortality, reduced productivity, and condemnation at dressing plants. Provision of proper environmental conditions is very important in disease prevention, and the design of environmental control systems, especially ventilation systems, is very important in preventing the spread of disease. Fundamental information is needed concerning the relation of environmental conditions to disease incidence, and new diseases create continually changing problems of control.

Major engineering objectives of the research are:

1. Determining the relation of thermal factors, air pollution, and ventilation rate to growth efficiency and disease incidence.
2. Developing and evaluating design criteria for structures and related equipment for environmental control in broiler production.
3. Developing and evaluating design criteria for electric equipment and control systems for environmental control in broiler houses.
4. Designing and evaluating brooding systems for chicks and poult to sustain rapid growth with minimum disease incidence.

### Progress - USDA and Cooperative Programs

#### A. Broilers

At the Southeast Poultry Research Laboratory, Athens, Georgia, data from four additional tests of effect of air velocity on heat tolerance support previous conclusion that increasing air velocity reduces physiological strain at air temperatures below 105° F. Data from four tests of constant temperature vs. large diurnal cycles indicate that growth is faster and physiological strain less under constant temperatures than under cyclic. Improved isolation cabinets for infectious-disease research were designed and 72 were installed and equipped with accessories. Two improved ventilation systems to provide filtered air under positive pressure to prevent disease transmission were designed and installed in poultry houses. Air-handling and -filtering systems were designed for six new environmental cabinets.

Studies at the South Central Poultry Research Laboratory, State College, Mississippi, of direct temperature-stress effects on condemnation of broilers relatively disease-free, or infected only with Mycoplasma gallisepticum, indicate that temperature alone is not an important stress factor. In a study where Mycoplasma gallisepticum-infected broilers were also infected with bronchitis, management factors such as low ventilation and high bird density, which adversely affected litter condition, dust, and ammonia, significantly increased condemnation due to airsacculitis. Low-cost radio telemetry

equipment has been developed which is suitable for telemetering the body temperature of 50- to 2,000-gram chickens up to 20 feet. Equipment requirements and techniques were developed for precise control of temperature, humidity, and ventilation in poultry environmental research chambers. A controlled-environment broiler house has been equipped for measurement of heat and moisture production of broilers on a whole-house basis, and a computer program for processing of the data has been developed.

In other studies at State College, a diurnal cyclic ambient temperature ( $40^{\circ}$  -  $60^{\circ}$  F.) for the brooding period compared to a program of  $95^{\circ}$  first week,  $90^{\circ}$  second week,  $80^{\circ}$  third week, and  $70^{\circ}$  F. fourth week of age produced chicks that had lower body weight, higher mortality, and higher feed conversion. Broiler chicks grown from 4-8 weeks under the above cyclic temperature had a higher condemnation, mortality, and feed conversion than chicks grown under a  $60^{\circ}$  F. ambient temperature. Broiler chicks grown in pens with restricted ventilation had a lower body weight and a higher condemnation than in better ventilated pens. The ammonia and carbon dioxide concentrations and moisture content of litter in these restricted ventilation pens were higher, but this was not necessarily true with dust.

#### B. Turkeys - Minnesota Agricultural Experiment Station cooperating.

Starveout and smothering account for 20 percent of the turkey losses. Continuing experiments with various brooding systems show how these losses can be reduced. By providing a higher temperature level around the hover area poult will venture out to look for food. It also eliminates cold spots where they are likely to pile up. The extra heat is provided by a perimeter-type heating system in addition to regular brooders. In one experiment, a pen with four gas hovers as the only source of heat was compared to a pen with four electric hovers supplemented with finned-type hot water radiation along the outside wall. The mortality in the former pen was 12 percent while it was 3 percent in the latter pen.

A preliminary brooding experiment was conducted to determine the effect of extra handling of poult on Round Heart disease. Poult from the same hatch with minimum handling suffered less than 1 percent mortality. Poult handled weekly for weighing averaged 7 percent mortality. Variations between pens also implicate chilling as an important factor.

#### Publications - USDA and Cooperative Program

##### Broilers

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#### Turkeys

JUNNILA, W. A. Turkeys do better in warm pens. *Agr. Res.*, USDA. Mar. 1968.

IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF  
FRUIT AND VEGETABLE CROPS  
(RPA 304)

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-years FY 1968
Kansas (Manhattan)	CO <sub>2</sub> Enrichment 1.0
Maryland (Beltsville)	Plant Growth Chambers 2.6
	Total 3.6

### Problems and Objectives

One means of increasing the growth-efficiency of existing plant material is to optimize the environmental conditions. Much fundamental information is still needed about the effects on growth of particular environmental factors, particularly light (and other radiant energy) and gaseous components of the atmosphere. Interactions among these factors are not yet fully understood and information about response differences between plant species is limited.

Engineering objectives of the research include development of design criteria for:

1. Equipment and control systems for applying CO<sub>2</sub> to plants by using carbonated water and other sources.
2. Structures and related equipment for controlling plant environments.
3. Lighting, electrical equipment, and controls to modify environment for plant production.

### Progress - USDA and Cooperative Programs

#### A. Carbon-Dioxide Enrichment

In cooperative work with the Kansas Agricultural Experiment Station, Manhattan, work in greenhouses using carbonated water mists continued to show improved growth of chrysanthemums as compared to plants misted with tap water. Differences were less in cooler greenhouse environment. Similar studies with leaf lettuce in temperature-controlled chambers indicate carbonated mist was most effective at 90° F., with 24 hours of light. The effectiveness was indicated by analysis of sugar and starch content of plants. Microscopic examination of plant stomata was initiated to determine physical response to environment.

Studies of optimum carbon dioxide levels at Beltsville, Maryland, in cooperation with Crops Research Division indicated that interacting factors need to be adjusted also. The light level, temperature, and nutrient application rate should be modified when the level of CO<sub>2</sub> is increased.

#### B. Plant Growth Chambers

At Beltsville, in the Phyto-Engineering Laboratory, visual observations of germination and seedling growth in temperatures between 65° and 105° F. indicate that young plants may respond to warm temperatures for early growth, like young animals. Temperatures used by the horticultural trade (75° F. night) are below the optimum for common species including petunia, ageratum, marigold, tomato, cucumber, and lettuce.

The Motion Meter, recently developed, has been modified to measure leaf thickness of alfalfa and will be used by alfalfa breeders, and others, to determine desirable leaf thicknesses for various plant uses.

Environmental control for small greenhouses is being studied in two "hobby" greenhouses which are heated and cooled by a domestic heat pump.

Publications - USDA and Cooperative Program

CATHEY, H. M., KLUETER, H. H., and BAILEY, W. A. Indoor gardens for decorative plants. Home and Garden Bull. No. 133, USDA. Dec. 1967.

KLUETER, H. H., DOWNS, R. J., BAILEY, W. A., and KRIZEK, D. T. To record plant growth. Agr. Engr. J. pp., 720-721. Dec. 1967.

BAILEY, W. A. Fan and pad cooling of greenhouses. Acta Hort. 6. 1968.

MECHANIZATION OF FRUIT AND VEGETABLE CROP PRODUCTION  
(RPA 305)

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Maryland (Beltsville)	Vegetable	.5
Georgia	Vegetable	.2
California	Vegetable	1.0
Minnesota	Vegetable	.5
Michigan	Deciduous fruit	3.0
California	Deciduous fruit	.5
Washington	Deciduous fruit	2.0
Florida	Citrus	3.0
California	Citrus	1.0
California	Dates	1.0
Hawaii	Coffee	1.0
Louisiana	Tung	1.0
	Total	14.7

Intramural program is supplemented by extramural support representing 1 SMY at other U.S. institutions.

### Problems and Objectives

Over one-fourth of all farm labor used for the production of crops in the United States is expended on fruits and vegetables. Although the number of man-hours has remained approximately static over the last 10 years, the percentage of the overall farm labor devoted to these crops has steadily increased. Thus the labor to produce the rapidly increasing volume has barely been offset by the labor-saving devices that have been put in use. The steady trend toward a decreasing supply of farm labor, particularly seasonal workers on which the growers depend most heavily, forecasts an even tighter labor market that can only result in reduced production if labor saving machines are not made available to the industry.

Major objectives of the research are to develop and evaluate alternative ways for:

1. The study of rheological properties of fruits and vegetables as they are related to mechanical harvesting and handling operations.
2. The development of machines and machine components to plant, cultivate, and harvest these crops.
3. The modification of trees and plants in order to facilitate the use of labor-saving devices.
4. The development of tillage units and the component equipment to minimize power requirements, reduce the number of field operations, and provide optimum seedbed and harvesting conditions.

### Progress - USDA and Cooperative Programs

#### A. Vegetable

1. Planting and fertilizing equipment. Two special machines designed and constructed were used to put in six cooperative field experiments at two locations in the East. Four machines were used in seven locations for nine cooperative experiments in the West, and two special machines were used to put in five cooperative field experiments at two different locations in the Southeast. Potato yields in the East were increased 49 cwt./acre (14 percent) by firming seed pieces with double seed firming wheels in comparison to the common loose covering by hillling disks. Potato yields with 24-inch row spacings increased 65 cwt./acre and 92 cwt./acre (18 and 27 percent) when compared with 30- and 36-inch row spacings. Seed pieces per acre were kept constant for all three row spacings. Production per plant increased for all row spacings as plant spacing increased down the row. In 36-inch rows increasing spacing 50 percent from 11 inches to 16 1/2 inches increased yields per plant from 2.14 to 3.53 pounds or 66 percent. In comparing crop

response to liquid and dry fertilizers with three vegetable crops in Florida, one of the three crops showed highly significant increases in crop production for the dry-type fertilizer. No response on snap beans or peppers. With cabbage, 1,800 lbs./acre 6-8-8 dry fertilizer produced on the average 110 cwt./acre over the same fertilizer in liquid form (65 percent yield increase). This production was from all the fertilizer side-placed at time of planting. Split time of application gave similar response although the crop production was less (but not significantly less).

In Western Washington potato yields were significantly higher where fertilizer had all elements mixed and in two bands to the sides of the seed pieces in comparison to separate positions of NPK, or broadcast patterns (15.2 to 17.6 tons/acre or 16 percent increase). Application of small amounts of M-P as pop-up fertilizer (3N-6P added to 125N-166P lbs./acre) showed some benefit on sweet corn and snap beans overall as side placement or broadcast, but may be hazardous in dry weather.

2. Harvesting and Handling Equipment. Engineering research on mechanically harvesting vegetables was initiated in October 1967. The major effort to date has been planning, getting facilities for offices and shop, and in hiring personnel. Office space has been obtained in an existing USDA building and a new shop of approximately 40 x 100 feet is under construction. No active research such as construction of experimental equipment has commenced. Harvest and handling operations of crops such as celery, broccoli, and cauliflower have been observed. A library study of past and present research has been made and a file of available harvesting equipment has been compiled. A tentative list of crops was made, rating them for priority of research attention.

3. Harvesting potatoes. The results of an engineering cost study of producing and harvesting potatoes were analyzed and published. This publication should prove extremely useful to growers improving the efficiency of their operations. A study of multirow harvesting was completed and a manuscript prepared which discusses advantages and disadvantages. This information will permit growers to decide when to use multirow harvesting. A tool for root pruning was designed and constructed and will be used in research on "Hollow Heart" disease. Engineering research on potato harvesting was terminated during FY 1968.

#### B. Deciduous Fruit

1. Properties of bark and wood. A study of living apple tree limbs was made because the ability of fruit wood to transmit vibrations is one of the factors to be taken into account when branch and tree shakers are designed. The position of a number of limbs, subjected to natural and applied loads, was measured by means of a surveyor's level. The loads were removed and the amount of permanent displacement measured. Other limbs were held out of their natural position and the amount of force required to keep them there was measured periodically for a seven-month

period. The results are being published and will be of value in shaping and training trees for mechanical harvest. Permanent changes in direction of growth of limbs are affected by physical properties of the wood, growth of new cells, and growth of limbs toward light.

2. Status of harvesting mechanization. A study of the current state of fruit harvest mechanization was initiated during 1967 under contract with Fresno State College, California. A survey for background information was conducted with equipment manufacturers, Federal and State research groups, and fruit growers. At the present time there is essentially no mechanization of fresh fruit. Considerable interest has been shown in the use of picking aids and for complete mechanization with the expected shortage of dependable labor. The main concern is the possible loss of qualified labor rather than the cost of hand harvest.

3. Harvesting studies in California. Studies of mechanical harvesting of cling peaches show that recovery of marketable fruit with machines was within 2-6 percent of that for hand harvesting. The 1967 yield of trees pruned in 1966 was the same as for unpruned trees. Trials on mechanical harvesting of apricots showed that no selectivity (mature and immature fruit) can be obtained with shakers. However, canning quality was satisfactory. A multilevel picking platform for hedge-row pears was studied. Results showed (1) picking into a bag on the unit was unsatisfactory due to its awkwardness and work stoppage while emptying the bag, (2) picking into a transfer tube was awkward and interfered with the picker's movements, (3) picking into a six-inch wide conveyor on the railing in front of the picker was satisfactory and increased his rate 21 percent over ladder and bag picking. A study of methods for collecting shake-harvested olives showed that a simple canvas on the ground is satisfactory as far as bruise damage is concerned.

4. Harvesting of processing apples. A study showed the most effective frequency for shake harvesting apples is between 400 and 600 cycles per minute and the best stroke is 3 to 5 inches. A shaker especially designed for apples is being constructed. A straddle-type continuous blueberry harvester was used experimentally in harvesting semidwarf apple trees. A modified cherry harvesting unit was again used in harvesting 14,000 bushels of apples. In cooperation with an equipment company a prototype roll-out collecting unit was designed and constructed. Preliminary results look promising. In an attempt to develop another type of low cost collection unit, a simple trailer containing 7.5- x 7- x 2/3-foot boxes was designed and constructed. The trailer was covered with two sets of decelerator strips. Although tests showed the unit has some possibilities, other equipment under test shows more promise. Another system was devised where apples can be collected in four shallow slope-sided containers each 16- x 16-feet. The containers are moved from tree to tree by fork-lift trucks. Time studies indicate a two-man crew can harvest 10 trees per hour. Another machine for picking up apples from the ground was designed and built. It used rubber discs covered with foam plastic. Ninety percent recovery rates were achieved and the apples were gently handled.

5. Harvesting of fresh market apples. A four-picker-position, tree-wall harvesting aid for apples was completed. Time study observations were made of four experienced pickers. Harvesting times for bag picking of three different tree shapes were compared. Average harvest time of the crew was reduced by 26.7 percent when picking with no aids in a dwarf tree-wall as compared to standard trees. It was found that harvesting aids for a crew of human pickers will operate at maximum efficiency only when the tree-walls have been trained for maximum fruiting efficiency. This is due to the small amount (10 to 15 percent) of nonpicking time involved in the bag picking of dwarf tree-walls. As the height of tree-walls increases through the use of other than dwarf trees, multilevel harvesting aids will become more practical, but tree uniformity must still be stressed for maximum harvesting efficiency as well as maximum yields. Pressure tests show that the lowest yield pressure for Golden Delicious apples was 10 times higher than average yield pressure of the firmest polyfoams. Therefore, polyfoam materials can safely be used on positive transfer conveyors. Research on bin fillers showed that a bin with a movable bottom is not feasible.

6. Harvesting of sweet and tart cherries. A study of methods of handling cherries in water showed that aeration does not prevent scald and that under certain conditions it causes objectionable darkening of the fruit. Investigation showed that the temperatures of cherries on the tree can be lowered 10 degrees or more by spraying the trees with cold water. Doing so decreased pitter loss and increased product yield and makes mechanical harvesting of tart cherries on hot days possible. A study of layout and construction of orchard cherry cooling stations was made and a report published. A study was made to determine the practicability of buying and selling cherries by volume rather than weight. Size of fruit, maturity, number of attached stems, and nesting of cherries affect the relationship of weight to volume only slightly. Bruising and firmness of cherries greatly affect the relationship and can cause as much as 10 percent change in bulk density. The study shows that buying cherries by volume would have the advantages of low cost, less bruising, and rewarding growers who deliver unbruised fruit. A tentative regulation for permitting buying and selling by volume is being prepared. A two-year study was made to determine the effects of immediate brining of sweet cherries on quality, change in weight, change in size, stem detachment force, and firmness was completed. Both bruised (mechanically harvested) and nonbruised cherries and cherries with stems and without stems were included in the tests. The results show that for best quality, the fruit should be brined within one hour after harvest.

#### C. Citrus Fruit

1. Tree modification to facilitate harvesting. The severe hedging of mature Valencia and Hamlin orange and grapefruit trees into six-foot thick tree walls has produced consistently poor yields of fruit over the past three years. Eight-year-old Pineapple orange trees, hedged in February

1967, yielded 2.7 boxes per tree compared to 3.0 boxes per tree in unhedged trees on the same 15- x 14-foot tree spacing. Close spaced trees on beds in the East Coast area of Florida continue in a tree-wall-shaping program but have not come into bearing. Tree pruning experiments to improve the efficiency of the tree shaker-catch frame harvest system were completed this season. Pruning an access hole for the tree shakers and removal of "unshakeable" limbs did not increase the system efficiency significantly over simply raising the tree "skirts."

2. Fruit loosening studies. The metabolism of iodoacetic acid by orange leaves was studied. Fifty-three other chemicals were tested for their abscission-promoting activity on Pineapple and Valencia orange explants. Shaker harvest trials using abscission chemicals were continued in the field. Fruit removal, quality checks, and harvest time studies were made using ascorbic acid and a mixture of erythorbic and citric acids as abscission-inducing chemicals. Harvest rate of the tree shaker-catch frame system was increased 17 percent using ascorbic acid and 11 percent using the mixture of erythorbic and citric acids as preharvest sprays. Fruit removal was not increased, but the fruit received less damage and had fewer attached stems than the untreated fruit that was harvested. This phase of the research will continue to improve the economics of using preharvest sprays and verify results from season to season.

3. Harvesting for fresh market. Tree modification and deadwooding of Navel and Valencia oranges at Riverside and the Coachella Valley for use with canopy and limb shakers was initiated. Ascorbic acid and six other chemicals were studied for abscission promoting effects. Shake harvest tests on single-pick lemons and grapefruit in the Coachella Valley showed a fruit removal of 90 percent. Surface injury, rind oil spotting, and fruit with 1/2- to 3/4-inch stems are problems. A unit for destemming citrus was constructed and tests indicate it can remove 90 percent of stems from Navel oranges. A slatted surface consisting of small diameter tubing covered with insulation material shows promise for catching citrus. Tests of the experimental roller harvester indicate fruit size, roller spacing, and surface speed influence fruit detachment more than roller angle. Economic feasibility studies of mechanized citrus harvesting and man-positioners were made. Methods of maintaining fresh market quality of mechanically harvested citrus are being studied.

4. Harvesting for processing outlets. Several additional tree shaker units for citrus harvesting were manufactured and used. The air-blast harvester was developed into a complete harvest system by one company. The best auger diameter and spacing was determined and an 80-auger bank harvester is being constructed for test on Valencia oranges. The snapping shaker developed last year was tested on Valencia oranges to differentiate between the larger mature fruit and the small green fruit of next year's crop. The fruit removal differentiation was not significantly improved over the conventional inertia shaker, and the unit was abandoned. A privately developed foliage type shaker was tested on

Valencias with no better results than the snapping shaker. The prototype tree shaker-catch frame harvest system was given limited use by one processor in Hamlin oranges. Fruit was harvested and delivered to roadside for 26 cents per box compared to 36 cents per box for the hand-harvesting system in the same grove. A rubber fingered auger "brush" machine for picking up fruit from the ground was designed, built, and tested. The pickup conveyor did not operate well in dry sand and is being replaced with potato chain. A time study was made of different hand picking and drop methods.

#### D. Miscellaneous Fruit

1. Production of dates. Research aerial pollinization of dates was continued. About 500 acres were aerial pollinated at 1 1/2 quarts of pollen per acre on a two-day schedule. The yield and fruit set in 1967 for both aerial and hand-pollination were below normal and not as good as 1966 results. Based on temperature records for the past 60 years, only six percent of the years had average maximum temperature as cold or colder than 1967 and no other April on record was as cold as 1967. Studies are in progress to determine temperature-fruit set relationships. The application of pollen from harvesting towers and ground dusting rigs will also be investigated in 1968. Shaking tests to separate pollinated from unpollinated dates were unsuccessful. Sizing the fruit two to four weeks after harvest gave the best separation. Plastic rings were installed in 40 palms in an attempt to eliminate the tie down operation. The plastic rings did not keep their shape and steel rings will be evaluated in 1968.
2. Harvesting and handling of coffee. Improvements were made in the suspension, shaking action, and clamp of the circular motion shaker for harvesting coffee. Further research on mass harvesting equipment was discontinued and emphasis placed on hand-held picking aids. A number of electrically hand-operated shakers were developed by modifying reciprocating saws, hand drills, polishers, and chain saws. Various types of collecting devices were designed and tested--the best being a drop cloth with a raised edge on at least one side and a center emptying device. Field trials showed the equipment was highly satisfactory and six growers have made firm commitments to purchase shakers. Air blast equipment for leaf and trash separation and bounce equipment for separating mature and immature coffee were developed. Laboratory studies were made of the reaction of coffee tree laterals to circular motion vibration. A study to determine energy recovery rate of coffee cherries dropped on a steel plate was begun. The information acquired will be used to further develop equipment for separation of mature and immature fruit. Orchard modifications have been continued. Currently under study are trellising, rejuvenation, chemical growth regulators, and pruning methods.
3. Harvesting and handling of tung. Redesigned project-developed tung harvester to make it a self-propelled unit. This unit works more efficiently on the sloping, contoured rows than the previously developed

tractor-mounted model. An experimental stick remover on the harvester removed only about 20 percent of the sticks, with none under five inches in length being removed. In a test to determine whether herbicides could be used to control weeds and grasses in tung orchards, none of the four herbicides, each applied at two rates and two dates of application, gave satisfactory control for good harvesting conditions.

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IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF FIELD CROPS  
(RPA 307)

USDA and Cooperative Program

<u>Location of Intramural Work</u>		<u>Scientist</u>	
		<u>Man-years FY 1968</u>	
Nebraska (Lincoln)	Seed Treatment	1.0	
Tennessee (Knoxville)	Seed Treatment	1.0	
	Total	2.0	

### Problems and Objectives

Non-uniform or delayed germination of seeds is a serious problem in establishing adequate field "stands" of many crops. A further complication for some species is the large percentage of hard seed, that is, seed with impermeable seed coats. Treatment of seed to make germination more rapid and/or more uniform or to reduce the proportion of hard seed would reduce the uncertainty in establishing field crops and reduce costs for seed.

Objectives of the research are to develop equipment and methods for treating plant materials with electromagnetic radiation to:

1. Improve germination characteristics of seed.
2. Produce other desirable effects, such as increased water absorption.

### Progress - USDA and Cooperative Programs

1. Radiofrequency treatment. Work in cooperation with the Nebraska Agricultural Experiment Station at Lincoln confirmed the effectiveness of radiofrequency (RF) electrical treatments for safely reducing hard-seed content in alfalfa. Tests with 27 different seed lots showed that RF and infrared treatments were equally effective for reducing hard-seed content. Furthermore, RF-, infrared-, and glow-discharge-treated seed exposed to these three different types of electrical treatment 5 years ago germinated well in retesting, and beneficial effects of the three types of treatment were still evident. Seed quality had not deteriorated in storage as it does with mechanically scarified alfalfa seed.

Studies initiated this year on use of RF energy for drying of chopped alfalfa revealed that RF treatment for exposures longer than 30 seconds measurably accelerated the subsequent drying rate of alfalfa. No changes in protein content of the dried chopped alfalfa were found, but the carotene retention of the dried alfalfa was doubled by some RF treatments. Experimental RF treatment of pine seed revealed a noticeable acceleration of germination for seed lots of Digger and loblolly, but further work is necessary to properly evaluate the benefits of treatment. In tests with seeds of desert plants, germination of huisache was raised from 6 percent to 30 percent by RF treatment of samples conditioned at 0 degrees F. before exposure to RF electric fields. Substantial increases in germination of castorbeans were obtained with RF seed treatment.

2. Gas-plasma treatment. At Knoxville, in cooperation with the Tennessee Agricultural Experiment Station and Crops Research Division, work on developing glow-discharge or gas-plasma electrical equipment for treating seed to accelerate germination and emergence from the soil has included construction of a rotating treatment chamber to provide better uniformity of exposure for seed during treatment, assembly of a high-vacuum system, and increasing the frequency range of the treating equipment. Field tests of the effectiveness

of glow-discharge treatment on emergence of cottonseed at the Milan Field Station were inconclusive because of adverse weather conditions. At Knoxville, poor weather conditions also interfered with plantings of glow-discharge-treated cottonseed in experiments to evaluate glow-discharge treatment as a means of eliminating seed which produced seedlings of low vigor. A very limited quantity of seed was harvested because of early frost and late planting.

Hulls from glow-discharge-treated soybeans were found to be more easily removed from both an edible and a field variety than were those of untreated control samples. It was also discovered that oil extracted from treated soybeans contained a flocculated material which was not noted in the oil extracted from untreated soybeans. Identification of the flocculated material is being attempted, and oil and protein analyses are being made on the treated and untreated soybeans to learn whether possible advantages might be achieved for food products of soybeans or for commercial applications of soybean oil.

Publications - USDA and Cooperative Program

None

MECHANIZATION OF PRODUCTION OF FIELD CROPS  
(RPA 308)

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Mississippi	Cotton	14.0
Alabama	Cotton	.2
California	Cotton	1.5
Texas	Cotton	3.8
New Mexico	Cotton	5.5
South Carolina	Cotton	3.7
Georgia	Forage	1.9
Oregon	Forage	4.0
Maryland (Beltsville)	Forage	.5
Georgia	Peanuts	1.6
Virginia	Peanuts	3.0
Kentucky	Tobacco	2.0
Florida	Sugarcane	2.0
Georgia	Grain	.3
Maryland (Beltsville)	Grain	.5
Iowa	Grain	3.0
	Total	47.5

Intramural program is supplemented by extramural support representing 3.0 SMY at State Agricultural Experiment Stations.

### Problems and Objectives

In considering the three major items of capital outlay for the production of food and fiber crops--land, buildings, and machinery--it is generally conceded that the machinery costs exceed the others by a wide margin. Improvements and changes in present day farm machinery are continually taking place in order to adapt to new varieties, improved production practices, a need for higher efficiency, and changing handling and storage practices. The cost of owning and operating field equipment for most crops is the major expense of production, in some cases, amounting to nearly half the total returns to the producer from the sale of the crop. Harvesting equipment is the most sophisticated and highest cost of all agricultural machinery, requiring expert attention by the operator during its period of use. The four billion man-hours of labor and the six billion dollar machine costs used annually in operating American farms offers ample potential for fruitful results.

The major objectives of research on the mechanization of field crops include:

1. The development of machinery and improved machine components to plant, cultivate, harvest, and handle specific crops in order to minimize power requirements, reduce the number of field operations and provide optimum seedbed, growing, and harvesting conditions.
2. The development of precision devices and automated systems that reduce labor requirements.
3. The determination of the rheological properties of crops that relate to the harvesting, handling, and processing in order to design and adopt labor saving devices.
4. The modification of varieties and cultural practices to provide plants more easily adopted to mechanized operations and labor saving devices.
5. The development of more efficient automated systems that encompass all field and post harvest operations that handle, cure, dry, clean, gin, or otherwise prepare the crop for market.

### Progress - USDA and Cooperative Programs

#### A. Cotton

1. Equipment for production systems. A basic study of field deterioration properties of cotton stalks was begun. Stalks were cut into three lengths and placed at four depths in two soil types. Over-wintering deterioration

was determined by measuring the breaking strength of the samples. There was no significant difference in strength due to the length of the samples at any depth of burial. Samples buried at 2-, 4-, and 6-inch depths had significantly lower breaking strengths than the samples remaining on the surface for both soil types. There was a tendency of less breaking strength requirements in the clay soil for depths of 0 to 4 inches, and a tendency of slightly less breaking strength requirements in the sandy loam soil for depths of 4 to 6 inches.

A promising method of removing both cotton stalks and root stubble simultaneously was devised by adding high lift sweeps to a modified rotary cutter. Shaped beds were used as a guidance system for accurate planting and close cultivation and application of chemicals. The project-developed drum planter gave better stands, less compaction, earlier plant growth, and better yields on both regular and preshaped beds.

Bed planting gave more consistent results with preemergence herbicides. Preplant herbicides incorporated nine inches deep with a rotary tiller lowered cotton yields. The yields were six percent higher for double row cotton planted on 40-inch beds compared with single rows on 40-inch centers. Yield and survival of cotton plants were correlated with emergence time. A relationship has been established between average minimum soil temperature during initial emergence and the total time required for initial emergence under natural temperature variations. A field planter with a vacuum seed metering wheel was designed and built. An automatic, hydraulically-controlled tractor steering system was designed.

Minimum preplant tillage, precision tillage (subsoiling under row), and normal tillage were compared on clay soil. The precision tillage plot had lower soil strength under the row. In a study of the relationship of tillage and disease, optimum tillage (precision tillage and a permanent zone system) produced greater and earlier plant growth and fruiting. Wilt was more prevalent in these plots the first year, but not the second year. First year's results from a crop residue management study indicated no relationship between crop residue management and *Verticillium* wilt. A rotary cultivator-planter was developed for once-over seedbed preparation, planting, and incorporation of pesticides.

2. Equipment for pest control. Further refinements were made on a fluorescent dye technique used to evaluate soil incorporators. Three different ground driven band incorporators mixed the dye in the similar non-uniform pattern to a depth of one and a half to two inches. Broadcast incorporators varied, considerably, with the disc harrow incorporating to four inches. Better weed control was obtained by incorporating liquid formulations than with granular types. Cotton stand, plant height, and yield were significantly reduced by deeper incorporation depths of trifluralin and nitrinalin. Preliminary investigations of steam as a method of killing weeds were not encouraging.

3. Effect of mechanical damage on cottonseed quality. Low quality seed was consistently obtained from cotton exposed in the field for the length of time required for twice-over harvest. Quality was consistently lower from the bottom half of the plant when once-over harvest was used. Seed cotton at maximum moisture content of 13 percent can be stored at densities of 7 to 12 lbs./cu.ft.; and cotton with moisture content of 10 percent can be stored at a density of 20 lbs./cu. ft. for as long as 30 days without any loss in germination or increase in free fatty acid content. Seed cotton with moisture content of 14 to 15 percent can be stored only 5 to 10 days without impairing quality of the seed.

Impact of seed cotton against the 90 degree conveyor elbow at 6,000 ft./min. resulted in reductions in germination of cottonseed when seed moisture content was 14.4 percent and above. In some cases, these reductions were as high as 19 percent. At 8.3 percent moisture, about 4 percent of the seed coats were cracked by this impact. Cotton seed at 12 to 13 percent moisture were neither reduced in germination nor cracked appreciably. The seed in cotton bolls that have opened under slow drying conditions seem to be more susceptible to germination reductions by impact than those opened under favorable drying conditions.

All of the impact tests on the four cottonseed varieties have been completed. Data have been placed on IBM cards and will be analyzed and summarized in the final report to be issued at the end of this season. An abrasive seed testing apparatus was developed to (1) measure the coefficient of kinetic friction of cottonseed on various surfaces, and (2) study the effects of rolling cottonseed between two surfaces on seed germination and damage. In seed storage tests, a significant trend is developing that as storage time increases there is a very rapid decline in quality of acid delinted seed as compared to mechanically delinted, flame delinted, or gin run seed. This is particularly true where mechanical damage is involved.

4. Harvesting and field handling. Several degrees of defoliation ranging from undefoliated to dessicated and well defoliated treatments were evaluated by lint quality measurements on two varieties, smooth leaf and hairy leaf. The undefoliated plots yielded stronger fibers than all other treatments except the partially desiccated treatment. The smooth leaf variety had significantly less trash in both seed cotton and lint. Results from leaf wilting agents were erratic this year. In a harvest-scheduling test, once-over harvesting gave highest yields and net returns. Topping and side pruning for plant modification did not adversely affect yield, but a growth modifier chemical, cycocel, reduced yield. One newly-designed picker basket grate slightly reduced the foreign matter content of wagon samples. A finger-type cleaning device in the picker head showed some promise.

A study was conducted to develop a workable relationship between selected seed cotton cleaner design factors and the cleaning performance of the machine as applied to the type cleaner that might be used on a cotton harvester. Thirty-two treatment combinations were studied with the aid of a computer. Open space between grid bars was the dominant variable affecting cleaning. Grid bar diameter was second, saw-to-grid spacing and saw cylinder speed were intermediate, and seed cotton flow rate was least among the factors studied.

A narrow-row harvester is a proven machine for harvesting small plants in narrow row spacing. When narrow-row stormproof long staple cotton becomes a reality, harvesting equipment will be available. In seed cotton storage studies, data in 1966-67 indicated a pressure between 50 and 60 p.s.i. would be adequate to compress seed cotton to a density of 20 lbs./cu. ft. A density of 20-23 lbs./cu. ft. is the greatest density that can be used and not affect seed quality.

5. Seed cotton handling at gins. A hopper feeder was designed to receive seed cotton from a farm trailer. It handled loose cotton and cotton compressed to a density of 12 lbs./cu. ft. satisfactorily. In another project, a trailer unloading system was developed and demonstrated at rates up to 24.5 bales per hour. Results indicate the system affords 96 percent reduction in power costs and 66 percent reduction in labor requirements for high-capacity plants.

6. Trash collection and handling. Cotton which was tramped in the hopper bridged above the feed mechanism. A commercial inertial air cleaner was found to be 80 to 90 percent efficient in collecting material which emitted from the exhaust of a cyclone handling gin trash. A 90 degree elbow at the inlet of a cyclone causes the cyclone to lose twice as much dust as when it is fed from a straight pipe. To eliminate the efficiency loss, elbows should be at least 10 pipe diameters from the cyclone. Back pressure on a cyclone was found to be highest when handling air only. There was a 25 percent drop with the same air volume when trash began entering it. The amount of particulate matter at a given distance from a gin cannot be predicted by Sutton's equation. Field tests at two gins compared with calculated data indicated that the equation must be modified using field data to develop correction factors. A gin equipped with cyclones and a means for collecting the trash from the cyclones can account for 95 percent of the process weight of machine-picked cotton. A trash skimmer was found to be satisfactory for all except lint fly and fine dust. A wet scrubber will collect the remaining material but at high power cost. A polyurethane covered filter was found to be satisfactory for condenser exhausts having an efficiency of 92.6 percent. A commercial-type centrifugal separator was found to work effectively in providing suction for unloading cotton from a trailer and also collecting a high percentage of the foreign matter from the air being discharged. An experimental inertial separation chamber proved to be effective as a trash collector for the exhaust of the seed cotton unloading fan on a laboratory basis. When

operating dry it was found to have the same efficiency as the centrifugal separator. It was more effective operating wet than dry. However, when operating wet it is necessary that it be flushed periodically. These two devices, when connected in series with the centrifugal separator equipped with an impellor designed for handling fibrous material, will serve as an air source for unloading seed cotton and for collecting foreign matter discharged with the air through the unloading system of the laboratory gin. Studies show that poor lighting exists in most gins.

7. Lint packaging. A condenser speed control was developed for use in a packaging system and tested on a lint cleaner condenser. It was found to work satisfactorily, holding a constant bat thickness for improved operating efficiency.

8. Conditioning and cleaning. Introducing humid air into feeder chutes under the distributor gave insufficient exposure for adequate moisture regain. A stick and green leaf machine was found to give no fiber damage. A limb and stalk remover mounted on a stripper left one-third of the foreign matter in the field, showed grade improvement on early season cotton, and had no adverse effect on fiber properties. Seed cotton cleaning tests show that more efficient cleaning methods are needed. Old style feeders are as efficient as those employing the stick remover principle. Seed cotton cleaning causes minor seed damage when compared with the gin stand or picker. Conventional seed cotton and lint cleaning machinery remove sufficient bark to prevent price discounts. For maximum foreign matter removal with a minimum of fiber damage a saw tip speed of 3,456 ft./min. is optimum. Two lint cleaners are recommended for use on Mid-South cottons. A third lint cleaner cannot be justified from any standpoint. Two lint cleaners split-fed gave comparable grade to two lint cleaners tandem-fed. No advantage was found in using X-78 in the gin. There were no differences noted in static level, power requirements, or grade. A self-cleaning magnetic separator was designed and found to be effective in removing scrap metal from seed cotton. Plastic freezer bags were found to be unacceptable for storing cotton samples for moisture determination purposes.

A comparative test to determine the effectiveness of the Monoflow System in preserving cotton quality was undertaken with the Pilot Spinning Plant, Clemson, South Carolina. Spinning results are not available. Fiber tests indicated that the system responded as expected with the higher moisture content lots showing less fiber breakage and long length. The low moisture content lots contained less foreign matter after cleaning. The injection of humid air into the extractor-feeder and doffing system of a brush gin proved to be feasible and resulted in reduced static difficulties during lint cleaning and decreased fiber breakage.

Changing relative humidity during ginning has a significant effect on processing performance of seed cotton cleaning machinery and saw-type lint cleaners. Total waste in the lint decreased as the humidity level decreased. Staple length and 2.5 percent span length were greatest at

75 percent r.h. Fiber strength increased as the humidity level increased. Grade, price, and bale value increased with lint cleaning. Uniformity ratio decreased as number of lint cleaners increased. Increasing the processing rate of seed cotton cleaning machinery resulted in reduced cleaning efficiency but not sufficient to cause reduction in grade or monetary returns. Fiber quality elements were not affected. Increasing seed cotton cleaner cylinder speeds 425 to 500 r.p.m. resulted in more effective foreign matter removal, higher grade, and an increase of \$5 in bale value without significant changes in fiber properties.

6. Lint-seed separation and quality studies. Seed roll density contributes to neps but is not a major cause. Tests to determine the cause of mill "lap-ups" have been inconclusive. Different fibrographs combs were found to give comparable results on the Mesilla Park Sorter if their dimensions were similar and two operators could obtain comparable results using the instrument. Equations for comparing results of the sorter with results from the Suter Webb machine appeared promising. Moisture content at ginning has greater effect on fiber properties than temperature. There appeared to be some interactions between temperature and moisture content which will be investigated. Preliminary tests show that elaborate seed cotton cleaning with two stick and green leaf machines and two lint cleaners are necessary for cleaning cotton stripped after machine picking. The use value of the fiber was not affected. Pressure on the knife on roller gin roll coverings correlate directly with seed damage. More damage was noted in harvesting than in seed cotton cleaning. There was no measurable difference in seed damage between moderate and elaborate seed cotton cleaning. Increased knife to roller pressure decreased fiber slippage, thus increasing the ginning rate, but roll temperatures increased with pressure which tends to reduce roll life.

Seed damage appears to increase with increase in the peripheral speed of the gin saws with a corresponding decrease in germination. Bale values of Southeastern cottons were improved as much as \$16 per bale when ginned in accordance with laboratory recommendations. When holding cleaning machinery constant the grade can be increased by additional drying. This practice, however, causes reduction in spinning quality. Over the range of a test from 60° F. and 60 percent r.h. to 90° F. and 90 percent r.h. using small-scale equipment, it was found that fiber length and length uniformity decreased directly with relative humidity. Similar tests on large-scale equipment over a range of 18 to 60 percent r.h. and 51 to 70° F. gave similar results.

A technique was developed for obtaining cottonseed moisture in five hours rather than the conventional 12 hours. Progress was made toward developing a method for calculating lint moisture in 20 minutes instead of one hour required by the conventional method. Procedure was developed for separating various trash components found in seed cotton for quantitative and qualitative analysis. A method for measuring fiber length of seed cotton shows promise. Measurements made during development of a measure of static

electricity on lint cotton showed that increasing heat on cotton would decrease and then reverse the static charge. Tests did not show any advantage of defoliation, desiccation, or wilting agent treatments of cotton. Several designs of picker basket grates showed no grade improvement. The conveying system of a cotton picker increased seed damage from 10.4 to 17 percent. Tests showed a new type 12-inch gin saw used less energy than the conventional type. There was no advantage for larger diameter saws. Fibers which had been subjected to high temperatures when allowed to regain moisture would still break more readily than fibers which had not been heated. Fiber breakage rate decreased one percentage point for each two percentage points increase in fiber moisture regain. The effect of field exposure on electrical resistance of cotton fiber is small by comparison with the effect of moisture.

#### B. Forage

1. Planting equipment. In cooperation with the Georgia Agricultural Experiment Station, four specially developed machines were used to seed seven cooperative field experiments of forages at three locations in the Southeast. Some were on prepared seedbeds while others were interseeded in sods. In selecting suitable cool growing forages for Midland bermudagrass sods, eight permanent type species were interseeded. In the row spacing studies of tall fescues interseeded in hybrid bermudagrass in mountain areas (Midland), the cool growing grass produced more dry matter than the summer grasses. In the 8-inch spacing, the dry matter production was over 5 tons/acre, with the fescue outproducing the bermudagrass from four to six times on the monthly clippings. In the 16-inch row spacing, the forage production of fescue averaged two to three times that of bermudagrass. With 24-inch row spacing, bermudagrass slightly out-produced the fescue. All treatments produced approximately the same total tonnage regardless of the row spacing of the interseeded crop. One substantial advantage of the dual crop is in the saving of labor in livestock feeding by extending the pasturing time from three to six months.

At Beltsville, Maryland, three field experiments were conducted with a special sod interseeding machine. Some twelve different annual forages were interseeded in cool season grass sod (tall fescue). In the interseeding of winter grains in Midland bermudagrass, the dry matter production increased about 80 percent (2.9 tons/acre to 5.2). The total production increase was not the only increased benefit. Having forage during a longer period of time (in late fall and early spring) is a marked advantage to a farm enterprise as it reduces materially the amount of labor required in feeding livestock. A report was analyzed and completed in 1967 of an earlier series of field experiments to determine the limits of successfully establishing spring seeded grasses and legumes. Although the primary objective was not achieved for the two seasons studied, a definite correlation was attained between soil moisture conditions and survival of herbage stand. A formula was derived whereby the survival stand could be predicted from a given soil moisture condition during the period following the seeding.

2. Harvesting and farm processing Coastal bermudagrass. For the second consecutive year, there was no significant difference in either yield or protein content between irrigated and non-irrigated Coastal bermudagrass. Near isogenic lines of dwarf and tall millet were dehydrated. Although the short millet had a much higher ratio of leaves to stem, the stem was more succulent than that of the tall millet and there was no difference in processing energy requirements. Continued studies of most economical method of producing pellets for roughage indicate that small amounts of molasses and animal fat can be economically used.

3. Seed harvesting equipment and methods. An experimental double belt thresher was designed, constructed, and tested. Variables of belt texture, speed, clearance, and pressure, as well as rate of feed, were investigated. Tests with two legume and three grass crops on a one-foot wide belt unit gave capacities up to 1600 lb./hr. at the 90 percent threshed seed level. Seed damage was judged negligible. A thresher with a four-foot wide belt will have capacities comparable to a six-foot swath spike-tooth cylinder combine. Time-of-harvest studies in 1967 indicated that the optimum mowing time for creeping red fescue was at a seed moisture of 23 percent; for Chewings fescue, 40 percent; and for perennial ryegrass, 40 percent.

4. Seed processing equipment and methods. Crop seeds and contaminants from 18 seed mixtures were measured microscopically to help select optimum size screens or indents for removal of contaminants. Full-size units of the resilience separator and vibrator separator were constructed and are operating in processing plants. Magnetic cleaning studies showed that water levels were critical in removing contaminants from alfalfa and directly related to clean seed yields. Particle size distributions and performances of 10 iron powders showed excellent agreement between fineness and effectiveness of a powder in removing contaminants. Flat-shaped particles did a better job than blocky shapes of the same general size. Reuse of powder was found inefficient because fine particles were gradually removed, leaving progressively coarser powder. Investigation of seed feeders was continued. The first phase of these studies was observation of oscilloscope waveforms showing accelerations of the various vibrators. The scope signal was obtained from a piezoelectric accelerometer mounted on the vibrator tray. Some of the traces were photographed with a specially constructed Polaroid camera setup. A uniform flow seed feeder was developed. Direct drive by a synchronous motor insured a stable frequency for the vibrator tray and tests showed very uniform feed rates, even with changing temperature or voltage. A high-speed seed counter was developed making use of a photocell sensing circuit and an electronic counter.

#### C. Peanuts

1. Digger and shaker development. A new peanut inverting mechanism has been developed. The inverter, which attaches to the rear of conventional peanut diggers with minor modification, completely inverts the Virginia-

type, runner peanut. Instrumentation was set up to record environmental data related to windrow curing of three types of windrows, normal or random, nuts up and nuts down. Results indicated that peanut temperatures were more variable in the random windrow and less variable in the up windrow. Peanuts in the up windrow dried at a slightly faster rate than peanuts in the other windrows. Average daily drying rate in the field was about four percent per day for eight to nine days after digging.

2. Harvesting equipment. Peanuts inverted in the windrow dry at a faster rate during and immediately following poor drying conditions than peanuts in the conventional random windrow. When good drying conditions prevail, the type of windrow appears to have little effect on drying rate. Under all conditions, however, peanuts in the inverted windrow dry more uniformly than those in the random windrow. Losses appear to be little affected by type of windrow but show an increase with an increase in soil moisture. Large pods and long pegs appear to contribute to greater losses.

Under near-ideal digging and harvesting conditions, peanut digging and shaking losses amounted to about 80 percent of all harvesting losses. The digging and shaking losses were about the same and there were no significant differences between varieties. Clipping vine tops as much as 10 days prior to digging had no significant effect on losses or yield.

3. Drying and mold prevention studies. Tests to determine the effect of combine cylinder speed on peanut damage showed that cylinder speeds 27 percent below the manufacturer's recommended speed reduced visible hull damage 35 percent and LSK's 25 percent. Invisible hull damage increased as moisture content decreased. Total hull damage ranged from 40 to 68 percent. Fungi growth studies indicate that kernels from damaged pods are more susceptible to infection by *A. flavus* than kernels from sound pods. No aflatoxin was produced in either innoculated or uninoculated peanuts, collected after various field exposure conditions, which were held under conditions of constant temperature and humidity for four days. Holding under the same conditions for eight days did produce aflatoxin, with the greatest concentration developed at 85° F. and 30-40 percent moisture content.

Peanut kernel hardness appears to be rather closely related to drying air temperature rather than drying rate. Increasing windrow exposure time, and consequently lowering the moisture content, before beginning artificial drying, reduced kernel hardness. Drying rate, rather than maximum temperature, appears to have the greater effect on shelling damage.

Three major varieties of peanuts, combined 0, 3, and 7 days after digging were held under conditions of (1) no air flow, (2) 1.0 c.f.m./ft.<sup>3</sup> of peanuts, (3) N<sub>2</sub> atmosphere, and (4) CO<sub>2</sub> atmosphere, for 1, 2, or 3 days. Under any of these conditions, one or more samples produced aflatoxin. When peanuts were dried immediately following combining, only one treatment, which was exposed seven days in random windrow, had aflatoxin development. Separate tests indicate that peanuts dried to the moisture range of 15-30

percent and then rewet were more susceptible to aflatoxin development.

D. Burley Tobacco

1. Harvesting equipment and methods. Hydraulic control and power circuits have been designed for a stalk-cut harvester having the function to fasten base of cut stalks to continuous twine. A procedure has been developed for handling stalk-cut tobacco using portable curing frames, fork-lift agricultural tractors, and air-cure barns reduces housing labor from 40 to 20 man-hours per acre. Marketing of a steel frame is proposed by a project cooper-  
ator. Equipment has been designed for artificially casing cured tobacco on the frames, allowing scheduling of market preparation, independent of weather. Value of experimentally cured tobacco has been equivalent to conventionally handled and cured tobacco. In 1967 a two-acre demonstration farm was operated by a cooperator.

2. Curing equipment and techniques. Programmed curing of primed Burley tobacco by a standard drying curve which was selected on the basis of previous research, was satisfactory. Curing temperatures of 80° F. and 90° F. were compared where the drying curves were the same. Tobacco cured at 90° F. obtained a higher grade. Respiration heat generated by Burley tobacco during the cure was measured at air temperatures of 80°, 90°, and 110° F. The respiration rate reached a maximum of 13 to 18 B.t.u./hr./lb. dry matter after 25 to 35 hours of curing time. The maximum rate increased with temperature. The total quantity of respiration heat liberated in two weeks was the same for all temperatures. The dry matter equivalent of total heat liberated was about 20 percent of the dry matter. This heat was sufficient to vaporize about 40 percent of water which was removed from the tobacco. The moisture gain with time for temperatures of 40° F. to 70° F. and humidities of 75 percent to 95 percent r.h. were determined for cured Burley plants, leaves, and stalks. For a constant relative humidity, the time required to reach a constant moisture content decreased as tem-  
perature increased. For a constant temperature, the time required to reach a constant moisture content increased as humidity increased.

E. Sugarcane

1. Harvesting recumbent cane. Field tested several designs of cleaners for removing extraneous matter such as tops, leaves, and soil from sugar-  
cane. Approximately 50 percent of the trash was removed from cane con-  
taining 29 percent trash standing in field and 24 percent after burning. In some tests, trash contents were reduced to the range of 8 to 14 percent. A topping system using 90 durometer rubber spiral rolls was tested. A topper lifted the leaves and pulled the tops into the rolls where they were broken, or the spirals conveyed them into a cutting blade. The rolls contacted only about 25 percent of the tops. A final design of the auger harvesting system using a 30-inch diameter upper auger and an 18-inch diameter lower auger was tested and operated efficiently. This design is satisfactory for the heavier recumbent canes grown on flat land. Horse-

power requirements were very low compared with other harvesting systems. Types of square rolls, round rolls, spiral steel rolls, and spiral rubber rolls were used for cleaning in the conveyors. Agitation or tumbling of cane was not as good with the conveyor slats traveling over the rolls. Further tests were made with the notched-tooth cleaners in the conveyor. About 25 percent of the total trash in burned cane was removed by the rolls and notched-tooth cleaners in the conveyor. High-speed photographic studies were made on auger oriented fingers, cones, polygon roll cleaners, pneumatic trash systems, and on a chopping system. Results of the pneumatic cleaning studies indicate that air should be applied in the opposite direction from common practice to take advantage of centrifugal force differences on cane and trash.

2. Top and trash removal. Contract research was completed on developing and testing laboratory models of trash removal devices to produce cane for mill processing having a maximum of 5 percent extraneous material and a minimum of 95 percent millable cane. Methods that were investigated included pneumatic separation, controlled burning, experimental belts, notched tooth drum, and cleaning rolls of several configurations. Polygon shaped cleaning rolls studied under this project offer the greatest potential of any of the methods studied. The rolls are adapted for removing leaf trash, some immature tops, soil, and other extraneous material. However, they do not separate large rocks. The condition of the trash on the cane does not seem to affect the performance of the rolls. A large percentage of the trash is removed regardless of whether the material is green, dry, or wet. Immature cane is removed from the mature cane providing the immature stalk is grabbed by the cleaning rolls. Of the three shapes of polygon rolls tested, square and hexagonal rolls were the most effective. Optimum rotating speeds for the rolls is considered to be approximately 600 r.p.m. The optimum size on the rolls will vary depending upon the shape. The pocket formed by a pair of rolls should not exceed the average diameter of the cane being cleaned. The polygon cleaning rolls could be used within any system of the harvesting and milling operation.

#### F. Grain

1. Fertilization. In continuing the study of row spacing and fertilizer placement with small grains, some of the new high producing varieties were used this year. In this first year study, with NC 4672 (Blueboy) wheat variety, 4-inch row spacing contact fertilizer placement increased yields about 1/3 (31.5 bu./A to 42.0) over the common practice of 8-inch row spacing (fertilizer in contact with seed). But of the treatments with side placement of fertilizer, the 12-inch row spacing had the highest yields (38.5), which also was a greater yield than the 8-inch or 12-inch row spacing with fertilizer in contact with the seed. In comparing fertilizer application positions on spring wheat (SWC-Montana) the 8-inch depth, continuous band gave highest yields compared to 4-inch depth and surface applications. Starter fertilizer with seed (4 lbs. N and 4P) in general depressed production.

2. Drying principles and methods. Final analysis of data on counterflow drying was made and a report prepared. Tests showed drying time is related to initial and final corn moisture and to air temperature and humidity. Criteria were presented for optimizing drying capacity and thermal efficiency. No damage to germination was observed using air at 140° F. compared to maximum of 110° F. for conventional drying. Weekly samples of corn obtained from field were taken to show changes in moisture as corn matures. Samples were processed to study effects of heated air drying on dry matter content, test weight, and germination.

3. Quality deterioration during harvest, drying, and storage. A machine to shell corn by squeezing and rolling action was developed and tested. Ears were fed between two 12-inch wide opposing flat rubber belts traveling in opposite directions and at different speeds. Complete shelling was achieved at 35 percent kernel moisture. Shelling corn of 25 percent moisture resulted in less than two percent mechanical damage by visual inspection compared to 30 percent damage by current field harvesting machines. Mechanical damage is defined as any crack or minute fracture in seedcoat. Several sources of variation affect precision of visual inspection for determining mechanical damage in corn, including sample differences, differences among men, and man's inability to repeat damage estimate. Fast green dye did not improve precision. Studied relation of corn deterioration (measured by carbon dioxide production) to aflatoxin development. Of 72 samples, 10 had Aspergillus flavus mold, all 10 from corn above 20 percent moisture. Only two samples had aflatoxin after producing 22 and 28 grams of carbon dioxide per kilogram of dry matter and were very moldy in appearance. Initiated test of refrigerated storage of high-moisture shelled corn. A 6,000-bushel bin was filled with corn at 21 to 23 percent moisture in November and cooled to 35° F. within three days; to below 10° F. by January; and was still 27° F. on April 1. Initial test of two experimental chemical fungicides with 32 percent moisture shelled corn in storage indicated retarded mold development for one fungicide.

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ENVIRONMENTAL STRESS IN PRODUCTION OF LIVESTOCK AND POULTRY  
(RPA 312)

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Arizona (Tucson)	Dairy cattle	0.0
Missouri (Columbia)	Dairy cattle & sheep	1.0
California (Davis)	Beef cattle & swine	2.0
Maryland (Beltsville)	Poultry	1.0
	Total	4.0

Intramural program is supplemented by extramural support representing  
(a) 0.2 SMY's at State Agricultural Experiment Stations.

### Problems and Objectives

Livestock and poultry farmers sustain large losses each year from extremes in both high and low temperatures. The effect of environment needs to be documented in order to devise management systems that will protect animal health and provide for optimum production. The unfavorable spread between the operator's costs and returns accentuates this need. Future food needs as indicated by our continued increase in population along with losses in agricultural land to housing, roads and rural recreation facilities intensifies the need to increase future production.

Major objectives are to develop design criteria for:

1. Structures and related equipment to provide optimum environments for housing dairy cattle.
2. Structures and related equipment for providing optimum environments for livestock (principally beef cattle and swine) production.
3. Laying hen, broiler, and turkey houses.

### Progress - USDA and Cooperative Programs

#### A. Dairy Cattle Environmental Facilities

Analyses of data obtained during the air-conditioned dairy barn summer field study showed statistically significant increases in production due to environmental control (1.28 lb/cow-day in the hotter than normal summer; 0.96 lb/cow-day in the cooler than normal summer). The measured differences compared well with predicted production gains based on previous Climatic Laboratory research. An economic analysis of summer environmental control for dairy cattle was made for Missouri, and later extended to the Mid-Central Region of the U. S. This analysis indicated that environmental control should be considered in southern Missouri when cow production is at least 70 lb/day, with consequent summer production gains of 500 lb. or more. Laboratory tests of the effects of catecholamines on cutaneous moisture loss from cows showed epinephrine to cause statistically significant increases at ambient temperatures of 18° and 30° C; norepinephrine produced no significant effect at either temperature. In another laboratory study, exogenous heat loads of 300 kcal/hr applied to mature cows by means of heating coils in the rumen resulted in significant changes in body temperature; heat loads of 125 kcal/hr did not. A 15-week study was conducted in the laboratory on the effects of vapor pressure on the vaporization rates of yearling wethers at a constant 20° C temperature.

#### B. Livestock Environmental Facilities

Average gains from two tests (245 days total) with beef cattle on sloping concrete floors were 2.88, 2.59 and 2.23 lb/day with areas of 60, 40 and 20 sq. ft. Beef cattle fed 17% hay (June, July and August) did not gain differently with 60 or 90° F. drinking water; when fed 100% hay, however, there was a 30% increase in gain with the cooler water. Stalls did not improve winter gains of beef cattle. Average gains during three tests with pigs at temperatures 10° above optimum were 1.28, 1.17 and 1.08 lb/day for RH of 30, 60, and 90%. One test at 20° F. above optimum gave ADG of 0.85, 0.78 and 0.56 for RH of 20, 50, and 80%. Increase in vitamin A content of diet for young pigs did not improve rate of gain at 105° F. air temperature. A study of pig feeding habits showed a marked affect of environment on time of eating, and results of awakening pigs at night indicated increased weight gains over pigs not disturbed. Sprinkling intervals of 80 minutes are sufficient when using sprinklers for heat relief.

#### C. Poultry Environmental Facilities

Linear equations for heat and moisture emissions of the Beltsville broiler data were developed for three average liveweight classes. The equations for broilers averaging more than one-half pound to end of growing period showed standard error of estimates of less than one. Similar data for growing chicks from hatch to 0.3 pound liveweight showed variations ranging from less than one to 19.3. These data were applied to experimental broiler houses of the West Virginia Agricultural Experiment Station. Both the developed data and the instrument-recorded values were used in the calculations of the house heat and moisture transmissions. The figures based on the laboratory data agreed within 88% of the calculations employing the observed information. This close agreement is sufficient in engineering to declare the laboratory data applicable to broiler house ventilation and insulation design.

#### Publications - USDA and Cooperative Programs

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IMPROVED LIVESTOCK AND POULTRY PRODUCTION MANAGEMENT SYSTEMS  
(RPA 313)

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
California (Davis)	Dairy engineering	0.75
Minnesota (St. Paul)	Dairy engineering	1.0
Illinois (Urbana)	Livestock feeding	1.0
Washington (Pullman)	Livestock feeding	1.0
Maryland (College Park)	Livestock water systems	1.0
Maryland (Beltsville)	Poultry environment	1.0
	Total	5.75

### Problems and Objectives

The shortage of farm labor, its higher cost, along with the increase in the average size of farm has made it necessary to develop systems of management that will reduce the amount of labor per unit of production. New systems cannot be developed and be made effective without changes in farmstead layout and the addition of specialized automatic or semi-automatic equipment. Automatic controls must be developed and fitted to the specific equipment that is used to build up individualized production systems.

Major objectives of the research are to develop and evaluate:

1. Engineering principles for planning livestock and poultry production facilities to reduce costs.
2. Environmental equipment and facilities as well as other electric controls and equipment to automate livestock production and improve efficiency.

### Progress - USDA and Cooperative Programs

#### A. Principles of Planning Farm Labor-Saving Structures for Livestock

A comparison of Herringbone sizes must assume good buildings, well-planned, properly built and with the right amount of good equipment properly used. Sixty-one Herringbone dairy layouts were studied to determine their suitability for milking all sizes of California dairy herds. All sizes proved suitable if used properly. Wide variations in milking rates occurred in the (2-4) to (2-10) sizes. Only one (2-9) and (2-12) were available. The (2-12) proved satisfactory and better in some respects on a per operator basis than the (2-4). Wide variations in distances traveled by machine operators were usually due to improper use of labor or poor "routine" but sometimes faulty equipment required it. Most important variables that determine how many milking machines an operator can use properly are: operator training, ability and routine; time to prepare cows for milking; ability of cows to milk fast; arrangement of milking layout; equipment condition and controls; width and length of operator area. A (2-4) with 4 or 8 machines is maximum for one operator if herd averages no more than 4.5 min/cow. A better operator may use a (2-5) if herd average is 5 min. Similarly two compatible operators may use a (2-10) properly. In a (2-4) or (2-8) milking rate may be 40 to 45 cows/hr/operator; in a (2-5) or (2-10), 50 to 55 cows/hr/operator.

#### B. Time Standards for Performing Farmstead Work Elements

Free stall flat floor dairy housing with outside feeding cannot be recommended for use in cold climates because of its inherent cold weather manure handling problems. Data indicates that it might be useful in moderate climate areas with shorter periods (2 to 3 days) of sub-freezing weather. It may be adaptable to confinement beef production since the animal housing and feeding areas can be reduced and the need for clean animals is not as stringent.

Initial studies of waste handling of cattle in confinement housing with slat floors over an oxidation ditch has indicated a need for special equipment and precautions taken to provide for continuous operation to eliminate slug-loading and to reduce surface freezing. The use of sloping solid floors with slatted gutters will reduce the manure handling to a minimum, but under normal ventilation practices the relative humidity and odor problems are increased.

#### C. Automatic Electric Control Systems and Equipment for Livestock Production

An automatic control system has been devised for removing silage from an upright silo, adding metered amounts of concentrates, and conveying the feed to mangers. The auger-type feed meters and the winch for the silo unloader are driven by d.c. motors through solid-state electronic speed-regulation controls. These have proven reliable and sufficiently accurate for livestock feeding. Solid-state controls were also developed and tested for speed regulation of a.c. and d.c. motors for operating ventilating fans and feed meters. A solid-state thermistor speed control for a d.c. motor operating a ventilating fan is under test in a confinement-rearing building for swine.

A remote-control system to operate a prime-mover vehicle is being developed. An engine is operated at constant speed to supply energy for traction and for auxiliary equipment through hydraulic motors and electric motors. A hydrostatic transmission proved satisfactory for controlling forward and reverse speed. A 3-position (right-null-left) steering control is unstable, limiting speed to about 3 m.p.h., so modulation seems necessary. Remote control is accomplished with a tone-code system, using combinations of 2 of 10 tones to provide 45 discrete signals.

#### D. Electric Equipment for Removing Silage from Horizontal Silos

Improvements to the design of an electric unloader for trench silos were continued. An impeller-type cutter for loosening the silage was developed and tested to replace auger-type cutters previously used. The 2-blade impeller operating at 500 r.p.m. delivered about 145 lb. per min. per hp., compared to about 105 lb. per min. per hp. for the auger.

The impeller lifted all cut material at least 3 feet vertically, which is ample for pickup by a fork-type elevator. Two counter-rotating impellers are mounted in the cutting head with a reversible tilting mechanism to keep the lead unit higher than the trailing unit. In either travel direction the trailing impeller does all the cutting and cuts sidewise and up, lifting the material free from the stack.

Initial tests show that it is feasible to continuously monitor the weight output of a roughage unloading device (silo unloader) and use this signal to control a feed meter regulating concentrates to be mixed with the forage. Accurate proportioning of silage and concentrates is possible over a 4-fold change in the flow rate of the silage. Such regulated proportioning is necessary to permit continuous-flow blending of cattle rations from the output of bottom-mounted silo unloaders and other unloading devices from which output is quite variable.

#### E. Electric Equipment to Provide Sub-Circadian Periodicity in Poultry

For 5 years a system for environmental control of temperature, ventilation, and humidity has been maintained in a 1200-sq. ft. poultry house. The control was independent of outside seasonal and daily environment to provide a sub-circadian day (18-hour) for reproductive studies in poultry. Use of dual critical components prevented loss of environmental control at extreme temperatures and during servicing.

Experimental equipment for automatic recording of egg-lay of individual birds has consistently detected and recorded more than 90 percent of all eggs from 800 individual birds over a 2-year period. Omissions and errors are due to failures of electromechanical devices in sensing individual eggs.

#### Publications - USDA and Cooperative Programs

##### Automatic Electric Control Systems and Equipment for Livestock Production

OLVER, E. F., HARSHBARGER, K. E., and PUCKETT, H. B. Automatic bunk-feeding of dairy cattle. Illinois Res. 9(3):8-9, illus. 1967.

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BEES AND OTHER POLLINATING INSECTS  
(RPA 314)

USDA and Cooperative Program

<u>Location of Intramural Work</u>		<u>Scientist</u>	
		<u>Man-years FY 1968</u>	
Arizona (Tucson)	Labor Reduction	1.3	
Wisconsin (Madison)	Labor Reduction	1.0	
	Total	2.3	

### Problems and Objectives

Existing equipment and methods for apiary management and honey processing require much manual labor, some quite strenuous. Reduction of labor requirements would substantially reduce costs of apiary operation. Death of bee colonies from extreme weather conditions and from field exposure to insecticides also causes major economic losses which can be reduced by modifying hive environment.

Major objectives of the research are:

1. Development of equipment and methods to increase labor efficiency in beekeeping.
2. Development and improvement of hives and related equipment to create more favorable conditions for honey production and bee survival.

### Progress - USDA and Cooperative Programs

At Madison, Wisconsin, in cooperation with the Wisconsin Station and ENT Division, an experimental motor vehicle for servicing bee yards has shown advantages. Its boom attachment permits one man to weigh and service hives in less time than was required by two or more men. An air compressor mounted on the vehicle also provides air for a high-volume, low-pressure blowgun for removing bees from filled honey supers. The blowgun operates by venturi action of a 100-p.s.i. jet from the compressor; it is light in weight and requires only a small (1/4" ID) air supply line.

For bee watering, use of wood fiber material as an absorbent proved as satisfactory as coarse-pored synthetic sponge and is less expensive.

At Tucson, Arizona, in cooperation with the University of Arizona and ENT Division, trials of plastic materials for combs are in progress. From 25 materials screened for acceptability to the bees, 3 have been selected for use in a large-scale test. Plastic combs are more readily accepted by honey bees after a year of exposure. Tests to determine comb shape and cell size showed comb size to be a direct function of colony size. Cells in queenless colonies were irregular in shape. Average cell sizes were: queenless colonies 0.229", + or - 0.011"; worker cells 0.205", + or - 0.002"; and drone cells 0.253", + or - 0.004". Insulating hive bodies of expanded polystyrene bead-board coated with vinyl plastic have shown rapid deterioration of the surface coating in 1 year of use. The plasticizer of the coating also appears to affect bees adversely.

Studies of air flow within hives show bees do not increase air flow by "fanning" and that cooling is primarily from evaporation of water carried into the hive by the bees. Flight of bees from hives was successfully reduced by blowing air across the entrance, thus confining the bees during insecticide applications.

Publications - USDA and Cooperative Program

DETROY, B. F. Honey processing, packing, and distribution. Beekeeping in the United States, Agr. Res. Serv. Handbook No. 335:42-51. Aug. 1967.

OWENS, C. D., and DETROY, B. F. New engineering developments in beekeeping. Amer. Bee J. 108(3):104,106,108,110. Mar. 1968.

OWENS, C. D., and FARRAR, C. L. Electric heating of honey bee hives. U.S. Dept. Agr., Agr. Res. Serv. Tech. Bull. 1377, 24 pp. Nov. 1967.

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IMPROVEMENT OF GENERAL PURPOSE FARM SUPPLIES, EQUIPMENT, AND BUILDINGS  
(RPA 315)

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Maryland (Beltsville)	Building plans	2.5
Maryland (Beltsville)	Construction	0.4
Maryland (Beltsville)	Eggs	0.1
Iowa (Ames)	Electrical service	1.0
Maryland (Beltsville)	Light measurement	1.0
Maryland (Beltsville)	Safety	0.5
Maryland (Beltsville)	Storage structures	1.0
	Total	6.5

### Problems and Objectives

Research on all farm inputs is needed to lower production costs to combat the growing spread between the prices a farmer pays and the prices he receives. Prices of building materials and machinery have about doubled in the past 20 years while prices the farmer receives have increased only about 12-percent. More efficient buildings, machinery and systems are needed, especially to reduce labor per unit of production.

Major objectives are to develop and evaluate means to increase the efficiency of farm systems by:

1. Planning structures to meet different systems requirements.
2. Designing general purpose utility systems for farmsteads.
3. Designing equipment to fit individual systems needs.
4. Incorporating safety features in the design, construction and operation of production systems.
5. Making and disseminating working drawings of plans for farm structures and other equipment.

### Progress - USDA and Cooperative Programs

#### A. Farm Service Building Plan Development

The Cooperative Farm Building Plan Exchange prepares an illustrated publication from each design or working drawing. These are submitted to the Office of Information and are published as Miscellaneous Publications and printed in quantities as requested by the States.

To satisfy the needs of the farmer, 23 color TV tapes have been produced to be broadcast through 200 stations to publicize the latest research in farm service buildings.

#### B. Doubly-Ruled Shell Structural Systems for Farm and Rural Application

Two modified HP roof sections free of the limitations of an HP shell were designed and tested with loads up to 30 p.s.f. These tests showed that these designs were feasible for low-cost shelter construction. This project was discontinued in November 1967 in favor of higher priority work.

#### C. Measurement of Eggshell Strength with Radioactive Isotopes

In the third year of the project, a public patent was applied for by the USDA and AEC concerning the beta backscatter method of measuring shell strength. The first commercial instrument was made by Tracerlab, Inc. of Waltham, Massachusetts, during January 1968. This instrument was demonstrated at the Fact-Finding Conference of the Institute of Poultry Industries at Kansas City, Missouri, February 7-11, 1968.

Cooperative research with the Canada Department of Agriculture was started at their Research Center at Ottawa in March 1968. They are running a correlation of backscatter counts with other properties of the egg on more than 2,000 eggs. Inquiries from 23 foreign countries as well as those from the United States have been answered. A backscatter gage will be provided for the University of California researchers to permit them to classify eggshells prior to testing. This research is cooperative with the Handling and Facilities Research Branch of TFRD, ARS.

D. Electric Demand Characteristics of Farms and Farm Equipment

Data for three-phase motors operated on rotary phase converters have shown a maximum permissible continuous converter loading of approximately twice the converter hp. rating if temperature rise of connected motors is held within their ratings. Short-term demand studies have shown that the type of thermostat control used for electric heating influences the peak- to average-demand ratio. Ratios of 1.875-minute demand to maximum observed 15-minute demands for general farmsteads, dairy farms, and feeding operations can be as high as 1.48, 1.58, and 1.47, respectively.

A rural motor-starting application guide recommendation has been prepared for IEEE-ASAE approval to standardize policies and help in the application of large motors to farmstead loads.

A study of methods of reducing costs of wiring for economy housing has shown benefits can occur from initial planning and use of parallel load centers. An experimental differential thermostat suitable for application to storage and environmental control has been developed.

E. Ultraviolet and Visible Electromagnetic Irradiance of Lamps

Light transducers were developed for continuous recording of light levels (foot-candles) in plant growth chambers. Performance has been satisfactory in continuous monitoring of light levels up to 4,000 foot-candles. The light transducers make possible continuous monitoring of light, along with temperature and humidity, with standard recorders in environmental studies.

Photometers and methodology were evaluated for measuring and recording levels of moonlight intensity. A preliminary comparison of available photometers indicates variations in readings from one-half to twice the absolute levels.

Spectral energy distributions observed in aging fluorescent lamps show little or no significant shifts during useful life of lamps. This indicates that fluorescent lamps can be used in agricultural applications until the lumen output falls below specific requirements.

#### F. Safety Features for Rural Structures

Current work with safety oriented organizations, keeping abreast of the latest research has brought about improved safety design in our rural structures. Several committees of the American Society of Agricultural Engineers, Farm Safety Committee and Structures and Environment Committee have pointed toward establishing standards on fire safety in farm or rural building design and construction. It not only involves fire safety but physical safety in structural design.

#### G. Silo Design Criteria

A pilot experiment on silage cover requirements showed that: uncovered silage spoiled to a depth of seven inches in less than 15 days; sawdust and similarly permeable materials were of little use as cover; polyethylene sheets of 1 mil and 6 mil thickness were equally effective for covering unwilted alfalfa silage during a 2-month period; dry matter recoveries from several well-sealed treatments amounted to 94 percent. In five years of tests, aluminum linings failed to protect old concrete silos from further acid damage. On labor reduction in filling of horizontal silos on medium-size farms, preliminary study indicated that mechanization of this operation to a degree comparable to typical tower silo systems would cost more than for the tower silo.

#### Publications - USDA and Cooperative Programs

##### Farm Service Building Plan Development

AGRICULTURAL ENGINEERING RESEARCH DIVISION. Cabin with dormitory loft. (Plan No. 6013). USDA Miscellaneous Publication No. 1074, March. 1968.

AGRICULTURAL ENGINEERING RESEARCH DIVISION. Three-bedroom tenant house. (Plan No. 7182). USDA Miscellaneous Publication No. 1072, March. 1968.

AGRICULTURAL ENGINEERING RESEARCH DIVISION. Potato storage, 60,000 cwt., cross alley. (Plan No. 6018). USDA Miscellaneous Publication No. 1069, March. 1968.

AGRICULTURAL ENGINEERING RESEARCH DIVISION. Dairy housing equipment... permanent-type construction. (Plan No. 5977). USDA Miscellaneous Publication No. 1068, February. 1968.

AGRICULTURAL ENGINEERING RESEARCH DIVISION. Tilting squeeze for sheep. (Plan No. 6006). USDA Miscellaneous Publication No. 1067, February. 1968.

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AGRICULTURAL ENGINEERING RESEARCH DIVISION. Adirondack-type shelter. (Plan No. 5998). USDA Miscellaneous Publication No. 1055, June. 1967.

Doubly-Ruled Shell Structural Systems for Farm and Rural Application

LIU, ROBERT C., and TETER, N. C. Hyperbolic paraboloid shells built with wood products. IASS Bulletin No. 30, pp. 3-8, June. 1967.

Measurement of Eggshell Strength with Radioactive Isotopes

WILSON, S. P., MARKS, H. L., and JAMES, P. E. Associations among beta backscatter measurements and other measures of shell strength. Poultry Sci., January. 1968.

JAMES, P. E., and RETZER, H. J. Measuring eggshell strength by beta backscatter technique. Poultry Sci. XLVI(5), September. 1967.

Electric Demand Characteristics of Farms and Farm Equipment

SODERHOLM, L. H. Electrical systems for economy housing. Proc. Economy Housing Seminar, Lincoln, Nebraska. Published by ASAE PROC 367:49-50, 64, November. 1967.

CHARITY, L. F., ALTMAN, L. B., and CARNEY, C. C. Characteristics of rotary-type phase converters. Trans. ASAE, General Edition 10(4):505-507, 511. 1967.

ALTMAN, LANDY B., and CHARITY, L. F. Demand estimation for sizing distribution transformers and secondary services in rural areas. IEEE Trans. on Industry and General Applications. IGA-3(3):260-267, May/June. 1967.

Safety Features for Rural Structures

TIMMINS, MERRILL S. JR. Lightning protection for the farm. USDA Farmers' Bulletin No. 2136, January. 1968.

TIMMINS, MERRILL S. JR. Fire resistant construction of the home - of farm buildings. USDA Farmers' Bulletin No. 2227, September. 1967.

Silo Design Criteria

GORDON, C. H., DERBYSHIRE, J. C., and MENEAR, J. R. Conservation and feed value of low-moisture orchardgrass stored in gas-tight and bunker silos. J. Dairy Sci. 50(7):1109-1115. 1967.

INSURE FOOD PRODUCTS FREE OF TOXIC RESIDUES  
FROM AGRICULTURAL SOURCES  
(RPA 701)

USDA and Cooperative Program

<u>Location of Intramural Work</u>	<u>Scientist</u>	
		<u>Man-years FY 1968</u>
Maryland (Beltsville)	Cattle Insect Control	1.0
Texas (College Station)	Cattle Insect Control	1.0
Texas (Kerrville)	Cattle Insect Control	1.0
	Total	3.0

### Problems and Objectives

At present the primary method for controlling insects of cattle, particularly flies, is the use of chemical insecticides. Since these materials must be applied directly to the animals and are often used inside barns, there is a possibility of residue-contamination of meat, milk, and feed. Improved insect-control methods are needed to minimize the likelihood of contamination and to overcome insect tolerance for insecticides.

Principal objectives of the research are:

1. Development of physical methods for insect control.
2. Development of more efficient and precise methods for applying needed chemical insecticides, to use as little as possible with maximum effect.
3. Devising engineering methods and apparatus for evaluating insect responses to physical stimuli and reactions to chemical toxicants.
4. Evaluation of control methods combining physical and chemical principles.

### Progress - USDA and Cooperative Programs

1. Responses of flies to radiant energy. At Beltsville, Maryland, in cooperation with AH and ENT Divisions, laboratory tests of response of house flies to particular radiation wavelengths indicated effects from temperature, sex, and height of trap, but field tests gave contradictory results. Orange was more effective than ultraviolet at cool temperature in the lab, but orange was ineffective in barns during cool fall weather. A trap design was developed using a 15-watt fluorescent lamp and a cage to capture flies alive for tests comparing attractiveness of lamps. This eliminates influence of odors from charred insects observed with electrocutor grids previously used.

Numerous observations were made of the behavior of house flies in the vicinity of attractant lamps endeavoring to improve trap components and trapping procedures including effects of trap height, ambient light, lack of food or water, etc. Tests of these principles in barns are in progress.

Factors affecting design of attractant-toxicant traps were investigated: total surface area is directly related to effectiveness; absorbent coverings, such as gauze, are superior to metal or plastic screen for retaining insecticide; and "conventional" phosphor BL lamps are superior to Philips' phosphor or BLB lamps.

In cooperative work with the Texas Agricultural Experiment Station and ENT Division at College Station, experimental procedures and facilities for determining the flight activity of stable flies in response to low-energy infrared radiation were devised. Infrared radiation, visible radiation, temperature, and humidity could be independently controlled. Preliminary

tests indicated that stable flies do not respond to incident radiation at less than 0.15 Btu/ft.<sup>2</sup> x hr., with peak energy at 9.2 microns. There were slight indications of response at greater radiation levels. Further tests with greater radiation levels and varying environmental conditions will be performed.

2. Mechanical equipment for fly control. Improvements to an ultra-low-volume automatic cattle sprayer at Kerrville, Texas, conducted in cooperation with ENT Division, resulted in better performance and increased reliability during field testing. These tests indicated that a 0.5 percent Ciodrin solution applied at a rate of 1 ml. twice daily is sufficient to control horn flies on dairy cattle. Xylene solutions of coumaphos (0.5 percent and 1 percent), Shell-4072 (0.25 percent and 0.5 percent), and Shell-8447 (0.5 percent and 1 percent) applied at a rate of 1 ml. twice daily to dairy cows provided horn fly control without detectable residues in the milk. Methoxychlor (1 percent and 2 percent xylene solutions) applied in the same manner produced residues (0.001 p.p.m. to 0.010 p.p.m.) in the milk of treated cows.

Flight activity studies with stable flies indicated a higher level of activity in light than in darkness for both sexes and that males are more active than females regardless of light condition.

A study of the seasonal pattern of hair exchange on a cow indicates hair losses of 0.8 percent to 1 percent per day occur in the early spring and summer, the periods of heaviest insecticide use.

Publications - USDA and Cooperative Program

PICKENS, L. G., MORGAN, N. O., HARTSOCK, J. G., and SMITH, J. W. Dispersal patterns and populations of the house fly affected by sanitation and weather in rural Maryland. J. Econ. Entomol. 60(5):1250-1255. Oct. 1967.

REDUCTION OF HEALTH HAZARDS INVOLVED IN THE USE OF  
NONFOOD FARM PRODUCTS

RPA 709

USDA and Cooperative Program

<u>Location of Intramural Work</u>	<u>Commodity</u>	<u>Scientist Man-years FY 1968</u>
North Carolina (Raleigh)	Tobacco	Grant

Intramural program is supplemented by extramural support representing (a) 1.0 SMY's at State Agricultural Experiment Stations, (b) 0.0 SMY's at other U.S. institutions.

### Problems and Objectives

During recent years increasing evidence has accumulated on the possible relationship between smoking and certain health factors. Although research has not shown specific causal factors in relation to tobacco, the importance of advancing the knowledge of tobacco properties to permit modification and control has been emphasized in the interests of the tobacco industry and the public. The flavor and taste of the smoke from tobacco when it is burned are highly dependent upon the chemical properties of the cured tobacco leaf. The major components include nicotine, total and reducing sugars, total nitrogen, protein nitrogen, non-volatile acids and petroleum ether extractables. Various levels of these properties produce marked differences in the smoking characteristics. Variation in the chemical constituents of flue-cured tobacco may result from differences in variety; fertilization; climate; cultural practices; age, maturity, and position of the leaf on the stalk when harvested; and curing schedules and methods. During production and curing the tobacco plant is a metabolically active system, and each imposed variable affects in some manner the final chemical composition.

Research is needed on identification and control of pertinent leaf properties during production, harvesting and curing. Specific engineering objectives are:

1. To determine the influence of production and curing variables on chemical and physical properties of cured tobacco.
2. To develop simple, non-destructive methods for measuring the physical and chemical properties of tobacco during various stages of plant development and curing.
3. To develop methods and equipment for attaining the most desirable physical and environmental factors at the various stages of production and curing.

### Progress - USDA and Cooperative Programs

Research under grant is being carried on at North Carolina State University on measurement and control of physical properties of tobacco during growth and curing as these properties relate to health factors. Studies made on properties of tobacco during curing indicate that chlorophyll concentrations can be accurately measured on the living plant. Based on data collected on chlorophyll degradation during the yellowing phase, an instrument is being built to rapidly measure the degradation. These measurements can be used in initial sorting of tobacco used in research and in monitoring progress of curing. Fiber optics are being considered to facilitate remote measurements of optical properties. It appears that moisture and chlorophyll can be monitored remotely. Optical techniques for evaluating color changes are being investigated. Problems associated with colorimetric

measurements make it necessary to use correction factors for moisture content and other parameters. Dual-wave-length spectrophotometric techniques theoretically obviate data corrections. Spectrophotometric equipment was ordered, installed and thoroughly acceptance-tested. The relationship of chlorophyll concentration, flowering and chemical composition to maturity is being investigated. Hopefully these data indicate optimum time for harvest.

Tobacco growth tests are being conducted in growth chambers at eight different soil temperatures from 50° to 100°F. and at air temperatures ranging from 40° to 100°F. Previous studies have shown optimum soil temperatures of about 75°F. for an air temperature of 85° F. day and 70°F. night. Initial tests comparing soil tensiometer readings with water potential indicate a linear relationship. Studies of tobacco plant growth indicate that growth will have ceased when water potential reaches approximately 45 atmospheres. Environmental chamber studies were conducted to determine influence of process environment on various biochemical conversions and color changes. Uniform samples from weekly harvests were submitted to coloring temperatures of 87° and 105° F. at high relative humidity of 85 to 90 percent. Evaluations are underway for total nitrogen, total alkaloids, reducing sugars, polyphenols, and 3-beta sterols.

Publications - USDA and Cooperative Programs

None

HOUSING NEEDS OF RURAL FAMILIES  
(RPA 801)

USDA and Cooperative Programs

<u>Location of Intramural Work</u>	<u>Commodity</u>	<u>Scientist Man-years FY 1968</u>
Georgia (Athens)		0.3
Georgia (Athens)		0.6
Georgia (Athens)		1.1
Maryland (Beltsville)		1.0
Maryland (Beltsville)		1.0
Maryland (Beltsville)		1.0
	<u>Total</u>	<u>5.0</u>

### Problems and Objectives

About one million low-income families in rural areas need to replace their homes and four million need major repair or remodeling. About a million and a half of these homes endanger the health and safety of their occupants. It is estimated about a million and three-fourths who lived in substandard housing had incomes of less than \$3,000. In addition about 400,000 migrant farm workers are now in the labor stream. Adequate housing meeting the Department of Labor standards is needed for these workers at a price that the growers can afford to pay. This labor is essential for a substantial volume of food products and farm income--estimated at \$10 billion per year. More effort is needed to reduce construction costs through simplified framing, heating, plumbing and lighting.

Major objectives are to develop a new technology of house design and building that will:

1. Be adaptable to be constructed by unskilled labor (self-help).
2. Make maximum use of space.
3. Utilize less costly methods of fastening.
4. Utilize less costly materials for each purpose.

### Progress - USDA and Cooperative Programs

#### A. Attic Fan Arrangements for Comfort in Rural Housing for Low-Income Families

Field tests have been completed and a statistical analysis made. Ventilating the rooms at night by fan, closing windows in the morning and insulating the ceiling gave best control of maximum room air temperatures over 24-hour periods. Similar results obtained for 8 p.m.-Midnight except with attic ventilated in the afternoon. Fan ventilation of the attic in the afternoon reduced maximum room air temperatures for 24-hour periods with the roof insulated but did not with the ceiling insulated. Considering overall findings, insulating the ceiling, ventilating the attic in the afternoons and the rooms at night, and closing windows during the morning gave best results. Temperature differences were generally small but in all cases these reductions in temperatures and increased air movement improved body comfort.

#### B. Reducing Heat Losses and Noise Comfort in Rural Dwellings

Ten tests conducted with various drapery materials showed a greater variation in heat flow due to manner of draping than was encountered between drapery materials. Draperies hung without tight seals at valance and floor actually showed an increase in window heat losses beyond those of a bare window.

Eighty-four heat transfer tests of underlay, fibreboard and 12 carpets with and without underlay have been completed. Pile density appeared to be the primary factor influencing heat flow. Statistical analysis is underway. Acoustical properties of carpets and draperies have been determined. Heavy-weight cotton, wool and Acrilan carpets ranked respectively in descending order in absorbing airborne sound. Heavy nylon and Acrilan (except plain loop) carpets were better sound absorbers than light weight. Pattern loop Acrilan carpets were best sound absorbers and plain loop the poorest with pattern cut and plain cut in-between. Thirty-two and forty ounce hair-jute underlays gave similar results with all carpets; both were better than foam rubber. Most carpets required an underlay to qualify as an effective acoustical material. Lined cotton, rayon and rayon-acetate draperies, pleated, were effective acoustical materials but generally not as good as carpets.

C. Plans and Guides for Rural Housing for Low-Income Families

Developed plans for low-cost, three-bedroom, concrete block tenant house based on Mississippi design. Plans incorporated in USDA-State Plan Exchange. Nearing completion is a three-bedroom house designed with research findings for convenient, safe use of elderly wheelchair persons.

D. Plans for Housing for Migratory Agricultural Workers

Designs, economical in space and material, were developed for prototype units. Ten prototype structures were built in cooperation with Maryland and West Virginia growers to study performance of arrangements, materials and space needs. One large unit for 32 men is a new design concept with large, open, multiuse area and sleeping rooms opening into this area. One 8 by 16 feet and eight 10 by 12 feet units were built to study possibilities of portable housing. They provide cooking, eating and sleeping area for two men or sleeping for four men if adjacent to a multiuse area. They can be moved about or sold when no longer needed. Developed cooperative camps, recreation buildings, health units and classrooms for other grower groups and organizations. Experimental windows were developed. New roofing systems were studied. Space allotments of 15 and 30 square feet per person studied for sleeping was crowded but not detrimental to health. Achieved reduced space requirements of 40 square feet per person for sleeping for Labor Housing Regulations working with U. S. Department of Labor and Public Health Service. Space related to functional need of occupant.

E. Materials and Building Techniques for Housing for Migratory Agricultural Workers in the Southeast

New technique for building concrete block walls without mortar was studied. Concrete blocks were stacked dry and a surface bond thin coat was troweled on both sides. The coating was a cement water formulation

with other ingredients to improve plasticity, high early strength and water tightness. Chopped glass fiber filaments were added to give tensile and shear strength. These walls proved to be much stronger than ordinary walls with mortar joints and were highly waterproof. They cleaned and sanitized easily. Cost of walls was reduced about 25 percent. Windows with glass fiber panels were developed. Framing is simple, costs are reduced, and fiberglass windows withstand heavy abuse of migrant occupants. Two-inch thick concrete floors on grade with hog wire reinforcing reduced costs and were satisfactory on soils tested. Two prototype structures were built in cooperation with a South Carolina grower using these experimental features. Each unit provided sleeping area for two couples, or a family of six, or six single men. Units were cool, fire-resistant, strong, and cost \$3.60 per square foot of floor area.

F. Reducing Costs of Rural Housing for Low-Income Families

The peripheral circulation system was tested in a two-story house in West Virginia. Some changes are needed to heat the second floor satisfactorily. At Blacksburg, Virginia, a peripheral circulation system was installed in an existing one-story house. The crawl space was wet and musty; timbers were rotting and paint peeling on the exterior. In one month of operation the crawl space and timbers had become dry. Temperatures recorded in the rooms and occupant reactions indicated excellent functioning of the system. A molding has been developed for applying plastic film such as in green-houses and many other buildings. It should reduce wind damage to the film.

Publications - USDA and Cooperative Programs

Plans for Housing for Migratory Agricultural Workers

PARKER, W. R., RULE, R. H., JONES, R. W. III, and AGNANO, P. Family housing for migrant agricultural workers. USDA-ARS and HEW-PHS unnumbered publication, 21 pp., June. 1967.

Reducing Costs of Rural Housing for Low-Income Families

NEWMAN, JERRY O. An economical and efficient heating system for homes. USDA Production Research Report No. 99, 26 pp., Sept. 1967.

ALLEVIATE SOIL, WATER AND AIR POLLUTION  
(RPA 901)

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Georgia (Watkinsville)		1.0
Maryland (Beltsville)		2.0
Maryland (College Park)		1.2
Nebraska (Lincoln)		0.4
New York (Ithaca)		0.0
	Total	4.6

Intramural program is supplemented by extramural support representing  
(a) 0.6 SMY's at State Agricultural Experiment Stations.

### Problems and Objectives

Domestic livestock and poultry in the United States produce an estimated two billion tons of wastes each year. These wastes effuse offensive odors into the surrounding area; they provide a spawning ground for vermin; on drying, they are a source of unsavory dusts; under rainstorms they produce run-off high in biochemical oxygen demand; and they may be the source of certain infectious agents found in streams. On the basis of biochemical oxygen demand (BOD) the fecal wastes produced by the 107 million cattle alone in this country is equivalent to the human wastes of a population of over 1.6 billion persons; or about eight times our total population. In a smaller comparison the fecal wastes of a 10,000 bird laying flock in a poultry house 50 by 200 feet would be the equivalent to the wastes of a small rural community of 1400 persons. The urban sprawl and increased use of rural recreational areas is increasing the pressure on large cattle and poultry operations. While animal wastes, when produced in large concentrated installations, contribute to air pollution locally, the amounts contributed by decaying wastes, gasoline and diesel motors and high sulphur fuels are greater. The contamination of soil from farm, industrial and radioactive wastes is an important consideration.

Major objectives of the research are:

1. Develop methods and facilities for handling, reclaiming and/or disposing of farm animal wastes economically and with environmental pollution hazard or aesthetic nuisance.
2. Develop methods for excluding or removing pesticide pollutants from and preventing entry of pesticide pollutants into farmstead water supply systems.
3. Develop methods and facilities for disposal of surplus pesticides and pesticide containers.
4. Determine methods of decontaminating farmland exposed to radioactive material, and means of disposal of contaminated soil.

### Progress - USDA and Cooperative Programs

#### A. Pesticide Pollution of Farmstead Water Supplies in the Southeast

Laboratory studies were conducted to obtain background information concerning the adsorption of toxaphene, DDT and lindane by activated carbon. Commercially available carbon filters appear to effectively adsorb contaminants provided sufficient contact time is allowed. Ultrasonic mixing of carbon-water mixture did not prove as effective in speeding adsorption of contamination by carbon as did mechanical stirring. Water samples taken from cooperator's contaminated shallow well indicate only slight

reductions in contamination level after pumping approximately 20,000 gallons. Conventional carbon filter installed on this system seems effective in reducing contaminant level but filter life is short due to plugging of the filter by sedimentation.

B. Pesticide Pollution of Farmstead Water Supplies in the Northeast

The sampling of Maryland farmstead water supplies, begun in 1966, continues. Of 24 farm water supplies in Washington County, five contained chlorinated hydrocarbon pesticides at concentrations above 0.1 ppb. Highest concentration to date was 0.8 ppb of Lindane (BHC). Of 24 farm water supplies in Wicomico County, one contained chlorinated hydrocarbon pesticides above 0.1 ppb. Highest concentration to date was 1.0 ppb of Fusarex (TCNB). None of the above concentrations were above limits recommended in the Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior. A chlordane-contaminated well in Carroll County, Maryland has been sampled for 18 months. Chlordane concentrations have fluctuated between 30 ppb and 4 ppb. A small active carbon filter installed on one branch of the system reduces chlordane concentration to acceptable levels at a flow rate of 1 gpm.

C. Develop Method of Removing Radioactive Contaminants from Agricultural Land

Radioactivity uptake studies were conducted on sandy and loamy fields at Beltsville, Maryland in 1967. Four crops were planted on each of two types of seedbeds: normal plowed and disked, and harrowed without plowing. Each seedbed was subdivided into two treatments: one-half of the plots had fertilizer applied at the rate of 1000 pounds per acre; the other plots had only 500 pounds per acre applied. A total of 430 millicuries of phosphorus-32 radioactivity were sprayed on the plots before seedbed preparation. This isotope is taken up by the roots of the plants. The radioactivity was sprayed on an additional area at the end of the plots. A soil profile observation trench was dug through this. Soil samples were removed from the wall of the trench at various depths. The radioactivity in the soil samples was measured and plotted. Samples of the crops were removed repeatedly during the growing season and radioassays made. A comparison of factors affecting fallout indicate six highly significant factors influence the radioactivity uptake: growing time, crop type, crop vs time, type of soil, tillage, fertilizer vs tillage.

D. Farm Animal Wastes Management

The second hydroponics bed was put in operation using common crushed gravel as a filler material. There was no apparent difference over "pea gravel". Grass yields were in the range of 17+ tons/acre/year.

Odor control in poultry exhaust air seems to be related to dust control. Efficient filter pads for dust removal also removed all odor but that of ammonia.

Topsoil production studies are just getting underway. The purpose is to dispose of large quantities of manure on small area of land and to create salable topsoil.

E. Disposing of Surplus Pesticides and Pesticide Containers

Under the container and storage phase of project a series of compatibility tests were established. These were to determine interactions between disposable containers and stored materials and various parameters involved. A search for less conventional container materials is to be included in the study. A study of commercially available incinerators is underway. Apparently both a small "on-the-farm" unit and a "community" facility will be needed for disposal of pesticides and containers.

Publications - USDA and Cooperative Programs

None

CULTURE AND PROTECTION OF ORNAMENTALS AND TURF  
(RPA 906)

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Indiana (Lafayette)	Turf	0.5
	Total	0.5

### Problems and Objectives

Modification of environment through control of soil temperature is an effective aid in both culture and protection of ornamentals and turf.

Engineering objectives are to:

1. Evaluate the performance of electric equipment for soil warming.
2. Determine design parameters for electric soil-warming systems and devise control systems to maintain desired temperature conditions.

### Progress - USDA and Cooperative Programs

Various wire-insulating materials have been tested, the insulating effects of turf thatch and of plastic coverings compared, and the effectiveness of several time-rates of heating evaluated. The performance of three large-scale commercial installations is being observed and evaluated to define several fundamental relationships to work out management problems. This work is cooperative with Purdue University Agricultural Experiment Station and is supported by the Indiana Electric Association.

Investigations were continued at Lafayette, Indiana, to further check control systems and to develop a method for estimating energy use. Tests in Minnesota indicate snow cover is a major factor in the effectiveness of a turf heating program. A gradual reduction of heating during the winter was preferable to an abrupt termination of heating.

### Publications - USDA and Cooperative Program

None

IMPROVEMENT OF RURAL COMMUNITY INSTITUTIONS AND SERVICES  
(RPA 908)

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
India (Baroda)	Sewage	1.0 (PL-480)
India (Lucknow)	Sewage	1.0 (PL-480)
	Total	2.0

Intramural program is supplemented by extramural support representing (c) P.L. 480 funds in India representing 91,076.13 U. S. dollars equivalent.

### Problems and Objectives

The rate of urban development in rural areas is increasing due to modern transportation and communications. Uncoordinated development has led to inadequate community services that are costly to revise or remodel. Research is needed to determine means of controlling sanitation systems, prevent pollution and to evaluate possible use of algae developed in oxidation ponds as a source of protein, carbohydrates, fats and/or minerals for feed.

Major objectives of the research are to:

1. Reduce cost of rural community sewage treatment and disposal through optimum algal-protozoal and algal-bacterial symbiotic balances.
2. Develop methods and equipment for economical production, harvesting, handling, processing and feeding of sewage grown algae.

### Progress - USDA and Cooperative Programs

#### A. Use of Algae, Algae-Protozoa, and Algae-Bacteria Cultures in Sewage Treatment

In work under a P.L. 480 project in India zoogloea-forming colonies and bacteria from oxidation ponds have been isolated. The viscous scum formed in oxidation ponds was found to contain 8 percent fat and 0.2 percent poly-B-hydroxybutrate (PNB). The algae chlorella liberate an anti-bacterial substance chlorellin responsible for the coliform reduction in oxidation ponds.

#### B. Use of Sewage to Produce Algae for Livestock Feed

The preliminary work has started to give basic knowledge of seasonal succession of natural algal in raw sewage with special reference to its chemical composition and bacterial population. Study of the comparison of the algal and bacterial flora in raw and stabilized sewage with respect to its aging in different seasons of the year is also underway.

It is proposed to undertake a survey of algal flora and chemical composition of raw domestic sewage of the important town of Uttar Pradesh. The survey work will start in the first week of July.

Steps have been taken toward the construction of oxidation ponds for algae-harvesting in Lucknow. Blueprints are under preparation.

Publications - USDA and Cooperative Programs

AMIN, P. M., and GANPATI, S. V. Occurrence of zoogloea colonies and protozoans at different stages of sewage purification. Reprint No. 1. J. of Applied Microbiol. 15(1):17-21. Jan. 1967.

GANPATI, S. V., AMIN, P. M., and PARIKH, D. J. Studies on zoogloea colonies from stored raw sewage. Reprint No. 2. Water & Sewage Works, pp. 389-392. October 1967.